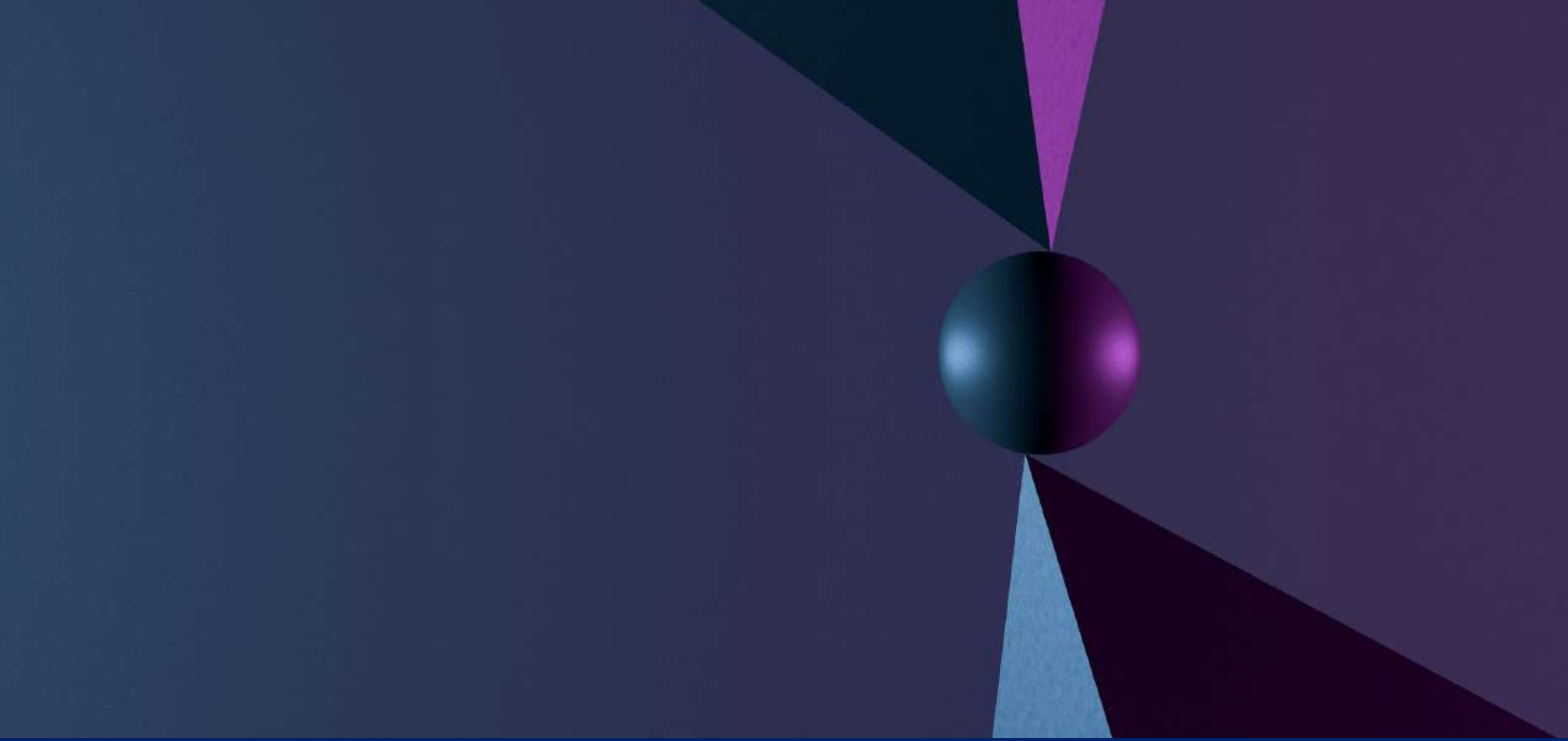

The Balancing Act: Risks and Benefits of Integrating Permanent Carbon Removals into the EU ETS

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CLEAN AIR TASK FORCE

CONCITO

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Executive Summary and Recommendations

The role of carbon removals in reaching EU climate targets is increasingly gaining traction and attention among policymakers and scientists in the EU. However, key **permanent carbon removals methods**, such as capture and storage of biogenic CO_2 from power plants or industrial processes (BioCCS)[1] and direct air carbon capture and storage (DACCS), currently sit outside of the EU's climate policy architecture, and the **policies needed to ensure their sustainable deployment in the EU are lacking**.

To address this gap, the European Commission has been mandated to assess by 2026 if and how CO_2 removed from the atmosphere and safely and permanently stored could be accounted for and covered by emissions trading.[2] This must be achieved without disincentivising necessary emission reductions and while ensuring environmental integrity, especially regarding the use of sustainably sourced biomass for BioCCS. Some of the policy options currently being explored by the European Commission are integrating permanent carbon removals into the existing EU Emissions Trading System (EU ETS), and creating a separate removal compliance mechanism, possibly connected directly or indirectly to the EU ETS.

The principal objective of the EU ETS is to cost-effectively reduce greenhouse gas emissions in line with EU climate targets. Any possible integration of permanent carbon removals into the EU ETS must be managed carefully to preserve this core function, ensuring that **deep, rapid, and sustained emission reductions** remain the top priority and cornerstone of the EU's climate policy. Permanent carbon removals should complement emission reduction efforts, not replace, delay or limit them. Further, a **portfolio of different permanent carbon removal technologies** is needed given the varied deployment potentials, trade-offs, and risks associated with each method.

1 In this report, BioCCS encompasses the capture and storage of biogenic CO_2 from all energy and industrial processes, including biogas production, while bio-energy CCS (BECCS) refers only to the capture and storage of biogenic CO_2 from combustion-based processes.

2 Directive 2003/87/EC.

The objective of this joint report from Clean Air Task Force (CATF) and CONCITO is to analyse and provide recommendations to address potential impacts on 1) the functioning and integrity of the EU ETS and 2) short and long-term demand for permanent carbon removals, if permanent carbon removals are to be integrated into the EU ETS as part of the 2026 review of the system.

This report examines the integration of permanent carbon removals into the EU ETS through four approaches:

1. Without restrictions
2. With a maintained emissions cap
3. With supply controls
4. Via an intermediary institution

Assessment criteria focusing on cost-effectiveness, environmental integrity, market functioning, implementability, and fiscal impact have been developed to evaluate the four policy options. The report focuses solely on BioCCS and DACCS in the base analysis due to their high permanence and robust monitoring, reporting, and verification (MRV). Biochar is included in a sensitivity analysis to better understand the effects of its possible integration in the EU ETS.

Main Findings

The analysis shows that integrating permanent carbon removals into the EU ETS would entail a careful balancing of trade-offs between environmental integrity, cost-effectiveness, and administrative/fiscal concerns.

Direct integration without restrictions would incentivise deployment of the cheapest permanent carbon removals first. It would help create **demand for these permanent carbon removals** and potentially lead to a substantial deployment of BioCCS from 2030 onwards depending on future allowance prices. However, the analysis indicates that due to the price differential between DACCS and the allowance price, DACCS deployment would most likely only occur with additional financial incentives, such as public funding and contributions from the voluntary carbon market. The EU ETS alone may not provide sufficient incentives for the early deployment of permanent carbon removals due to the prevailing allowance price.

Direct integration without restrictions risks leading to **deterrence of emissions reductions**. As carbon removals enter the system, companies under the EU ETS emit more by substituting emissions reductions with carbon removals, allowing gross emissions in the EU ETS to increase compared to a scenario with no integration. As a result, incentives for emissions reduction efforts could be lowered, hampering the environmental integrity of the system. Another important risk is the **unsustainable use of biomass**. In light of the lack of a carbon pricing regime in the land sector, increased biomass use for BioCCS could lead to land use change and, depending on the biomass feedstocks, negatively impact the already challenged carbon removals in the LULUCF sector. Without targeted restrictions on the quantity of carbon removals using biomass, the deployment of BioCCS could far exceed the levels assumed in the European Commission's impact assessment for the 2040 climate target, which are capped by constraints on the availability of sustainable biomass.

The findings of this report highlight the need to incorporate safeguards and specific design features if permanent carbon removals are integrated into the EU ETS, in order to ensure the environmental integrity of the system. Some of these safeguards, such as maintaining the emissions cap and applying supply controls, will, in some instances, negatively impact the demand for certain permanent carbon removals and the overall **cost-effectiveness** of the system, as well as **liquidity**; the latter impacting the functioning of the market.

In every policy option, integrating permanent carbon removals into the EU ETS increases the **administrative costs** for permanent carbon removal operators (setting up monitoring, reporting, and verification and selling at auctions or into secondary markets) and the regulator (setting up new design elements such as monitoring, reporting, and verification, delivery systems etc.). Integration will also have **fiscal impacts** by lowering auctioning revenues. These fiscal impacts are affected by the possible restrictions on integration and could be mitigated by the accompanying reduction in the level of public funding required for permanent carbon removals in some Member States.

In terms of **policy coherence**, integrating permanent removals directly into the EU ETS could contribute to bringing sectors covered by the EU ETS to net zero, but will likely be insufficient to achieve economy-wide climate neutrality in the EU. It would also be insufficient in delivering on the EU commitment of net-negative emissions after 2050, since the system will no longer provide incentives for permanent carbon removals beyond net zero, unless a net-negative emissions cap is designed with additional obligations.

Establishing an **intermediary institution** to manage the integration of permanent carbon removals into the EU ETS could mitigate some of the risks associated with direct integration. However, its institutional effectiveness would depend heavily on how it is designed, structured, and operated. The example of an intermediary institution put forward in this report could provide structured oversight, ensuring a controlled and gradual entry of permanent carbon removals into the EU ETS. It could also provide a strong incentive for technology deployment through direct procurement of different types of permanent carbon removals. The scale of the demand is uncertain and would depend on the level to which such a procurement scheme is funded, for example through EU ETS revenues and/or Member State contributions. Additionally, the main challenge of establishing an intermediary institution is the political feasibility of delegating these functions to the institution. This option could also involve higher administrative costs for regulators and possibly slower implementation compared to direct integration. While an intermediary institution can offer advantages, the risks associated with direct integration can be managed through safeguards within the framework of the EU ETS, and sufficient demand could be addressed by other supporting policies inside or outside of the EU ETS. The scope of the analysis is limited to procurement of permanent carbon removals into the EU ETS, and other possible functions of such an institution, such as managing the cap and allowances prices, are not analysed.

Integration of **biochar** in the EU ETS could affect deployment of other permanent carbon removals methods and amplify risks regarding deterrence of emissions reductions and sustainability due to its use of biomass resources and relatively low technology costs. CONCITO and Clean Air Task Force recommend the European Commission to carefully analyse the impacts of biochar on the environmental integrity of the EU ETS, deployment of BioCCS and DACCS, and demand for biomass resources. Any integration would need additional strict measures on permanence and liability.

Recommendations

If permanent carbon removals are integrated into the EU ETS as part of the 2026 review of the system, Clean Air Task Force and CONCITO recommend a **careful and gradual integration.** The following safeguards and design features should be integrated:

1. **Maintaining the gross emissions cap** for initial integration so for each extra carbon removal allowance entering the EU ETS, one fewer traditional emission allowance is released at auction. This could effectively address deterrence of emissions reductions and ensure the system continues to drive abatement.
2. Implement **supply controls on different permanent carbon removal methods** to address sustainability risks concerning biomass-based permanent carbon removals as well as manage potential fiscal impacts.
3. Introduce **rules on permanence and robust monitoring, reporting, and verification** to ensure that carbon removals provide a climate impact equivalent to the surrender of traditional emission allowances. Adjustments in methodologies under the framework for certifying permanent carbon removals, carbon farming and carbon storage in products (CRCF) could be needed (e.g. regarding life cycle calculations).
4. Introduce **differentiated allowances** to enable a regulatory distinction between traditional emissions allowances and allowances from different permanent carbon removals methods and to enhance information to market participants and policymakers.
5. Introduce a **review clause** to assess effects on environmental integrity and functioning of the EU ETS, before possibly adjusting safeguards and design features. The assessment should also take into account the abatement costs under the EU ETS and possible developments in other policies (e.g. better incentives/pricing in the land sector), when assessing the need for adjustments.

A suite of supporting policies should be considered ahead of and alongside an integration into the EU ETS to ensure a sustainable deployment of permanent carbon removals to fulfil their critical role in achieving net zero and net negative:

- **Separate reduction and removal targets in the 2040 EU climate policy framework** (e.g. separate targets or sub-targets for emissions reductions, LULUCF, and permanent carbon removals).
- **Additional EU funding tools**, such as public and public-private purchasing programmes, reverse auctioning, or carbon contracts for difference schemes, outside or in conjunction with the EU ETS (e.g. the Innovation Fund) should be examined to close possible gaps between the allowance price and permanent carbon removals, particularly for DACCS, while avoiding weakening the support for other technologies critical to provide deep and timely emission reductions.
- **Prioritisation and stronger regulation on the rising and competing use of biomass and biogenic CO_2** (e.g. improved incentives in the land sector) are needed in parallel with incentivising biomass-based permanent carbon removals.
- **Interlinkages with the voluntary carbon market** must be thoroughly assessed (e.g. ensuring additionality).
- Ensuring **appropriate regulation and coordinated development of EU-wide infrastructure** for transport and storage of CO_2, including the swift implementation of the Net-Zero Industry Act (NZIA) and the Industrial Carbon Management Strategy (ICMS).

A **final decision** on regulating permanent carbon removals would also require analysis of other policy options, such as introducing a separate compliance mechanism for carbon removals and using revenues from the EU ETS to support deployment, as well as other possible safeguards and design features, such as demand controls, related to integration into the EU ETS. The **2026 review of the EU ETS** will assess several other aspects (e.g. non-permanent carbon capture and utilisation), which can directly or indirectly affect a possible integration of permanent carbon removals. Furthermore, the emissions trading system for buildings, road transport and additional sectors (EU ETS2) and the possible introduction of an emissions trading system in the agricultural food value chain (AgETS) could also be subject to discussions on the integration of carbon removals. The safeguards and design features recommended in the report would to a great extent apply to any potential integration into other emissions trading systems.

Beyond climate neutrality, the EU will need **additional policies and measures to get to a net-negative EU** (such as Member States obligations, a net-negative emissions cap in the EU ETS, a carbon takeback obligation, a separate compliance mechanism etc.), all of which require further research. The trade-offs raised in this report between environmental integrity, cost-effectiveness, and administrative/fiscal concerns are also relevant for many other policy interventions in the area of carbon removals.

SECTION 1

Introduction

1.1 Objectives of the Report

The EU Emissions Trading System (EU ETS)[3] is a key tool for reducing greenhouse gas (GHG) emissions in line with the EU's binding climate targets, including achieving climate neutrality by 2050 at the latest.[4] Given the high likelihood of some limited residual emissions remaining by this date, as well as the EU's accompanying commitment to achieve net-negative emissions post-2050, the integration of carbon removals into the EU ETS is gaining increased attention among scientists and policymakers. As part of the revision of the EU ETS Directive, the European Commission is tasked with delivering a report by 2026 assessing the possibility of integrating permanent carbon removals into the EU ETS.[5] This joint report prepared by Clean Air Task Force (CATF) and CONCITO examines policy options for integrating permanent carbon removals into the EU ETS and their potential effects on a wide set of criteria, including on the functioning and integrity of the EU ETS as well as short- and long-term demand for permanent carbon removals.

The report lays out a path forward if permanent carbon removals are integrated into the EU ETS, looking at this complex policy issue through the lens of key assessment criteria and indicators, including the effect on the incentive for emissions reductions, the incentive for deploying permanent carbon removals, effects on market functioning, impacts on sustainability, and the implementability of the assessed policy options.

Types and Role of Carbon Removals

The international scientific community, including the Intergovernmental Panel on Climate Change (IPCC), has repeatedly emphasised the necessity of carbon removals for limiting global temperature rise in line with the Paris Agreement. As defined by the IPCC, carbon removals are a set of "anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products".[6] Carbon removal methods are commonly divided into those which increase the uptake and storage

3 European Commission (2024a).

4 European Commission (2024b).

5 DIRECTIVE (EU) 2023/959.

6 IPCC (2022).

of CO_2 by natural carbon sinks, such as forests and soils (known as nature-based solutions), and those which bind carbon in manmade sinks – variously referred to as 'permanent', 'novel', 'technical', 'engineered', or 'industrial' removals. This report focuses on permanent carbon removal methods involving the storage of biogenic[7] or atmospheric CO_2 in geological reservoirs, known respectively as BioCCS and direct air carbon capture and storage (DACCS), which are considered to be capable of delivering carbon removals with a high degree of permanence (see Section 1.3).[8]

In recent years, the need to scale carbon removals has gained significant traction among scientists and policymakers seeking to reduce the stock of atmospheric CO_2. The contribution of carbon removals to achieving climate targets can be usefully conceptualised as three distinct roles:

1. **In the near term, carbon removals are a means of reducing net emissions**, acting as a distinct source of abatement that contributes towards emissions reductions targets.
2. At the point of climate neutrality, **carbon removals are expected to be necessary to neutralise any remaining 'residual' emissions from hard-to-abate sectors**. In this capacity, carbon removals effectively constitutes the 'net' in 'net zero', and is a direct implication of such targets.
3. In the long term, **carbon removals will be needed to generate net-negative emissions**, whereby there is a negative flow of carbon from the atmosphere to tackle historical emissions and potentially correct for any temperature overshoot.

To stand at least a 50% chance of limiting global warming to 1.5°C with no or limited overshoot, realistic pathways project the need for 20 to 660 gigatonnes of negative CO_2 emissions globally up to 2100.[9]

While the need for permanent carbon removals is clear, the primary method for achieving net-zero is through ambitious decarbonisation efforts across all sectors. It is generally preferable in terms of both cost and climate impact to prevent an emission than to subsequently remove it, given the immediate climate impact of atmospheric CO_2 as well as the energy and resource requirements of permanent carbon removal.[10] However, marginal abatement cost curves (see Appendix 1) indicate that for some hard-to-abate sectors it will be more cost-effective to permanently remove an emission than to implement abatement at source. It must be noted that defining 'hard-to-abate sectors' and the 'marginal abatement costs' are constantly evolving with technology development. In any case, carbon removals must be complementary to emissions reductions; prioritising deeper emission cuts will reduce Europe's reliance on carbon removals in the future.

Scale of Carbon Removals in the EU

Modelling in the European Commission's impact assessment for the 2040 climate target indicates around 400 Mt of GHG emissions remaining by 2050 in the S3 scenario (see Figure 1). These emissions are dominated by the agricultural sector, with smaller contributions from waste management, the residential and service sector, industry, and transport. Land use, land use change and forestry (LULUCF) provides 330 Mt of net removals by 2050, and remaining emissions are balanced by 114 Mt of permanent carbon removals, equally split between BioCCS and DACCS.

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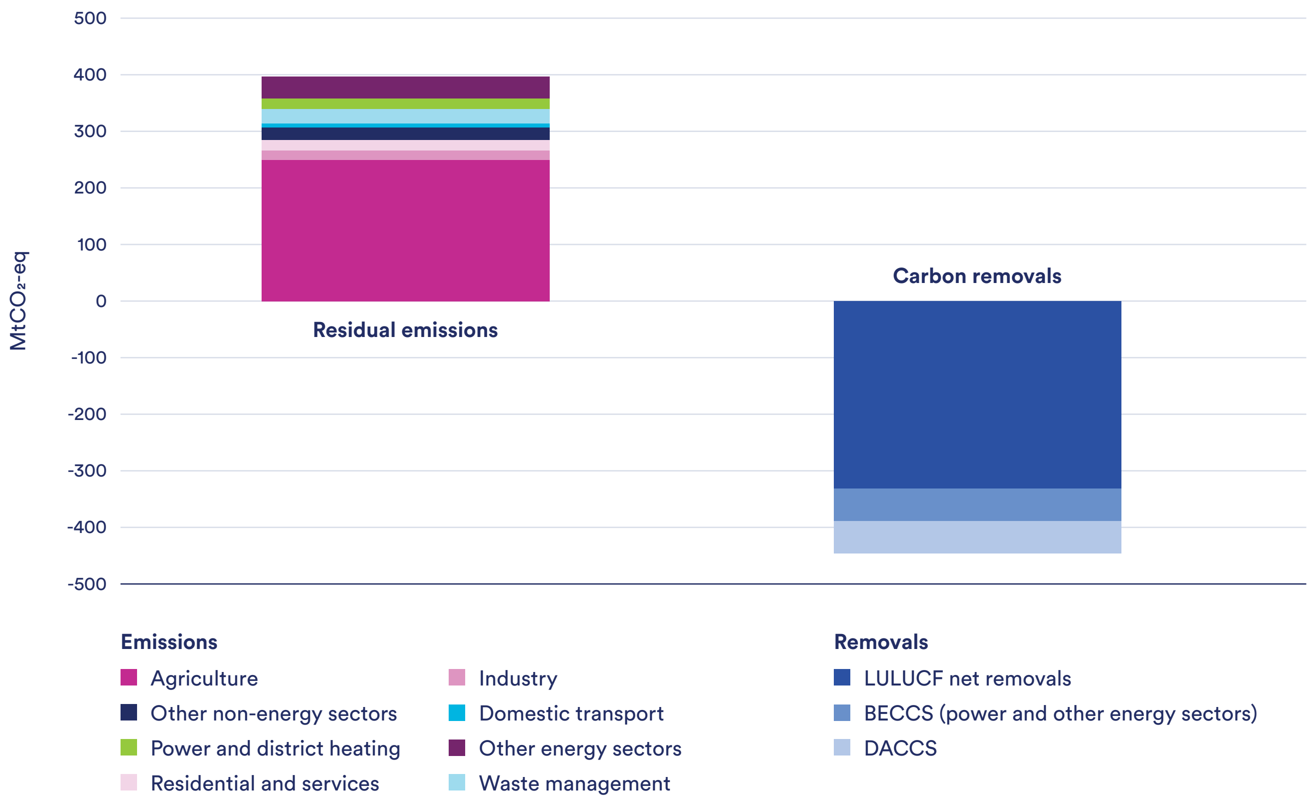
[7] Biogenic CO_2 originates from biological sources such as plants, soils, and microbes, and results from combustion, digestion, fermentation, or other processing of relatively recently fixed organic materials.

[8] The European Commission uses the term 'industrial carbon removals' to encompass these technologies based on the geological storage of CO_2. This report will use the term 'permanent carbon removals' throughout.

[9] IPCC (2022).

[10] Ben Caldecott & Injy Johnstone (2024).

Figure 1: GHG Emissions by Sector and Carbon Removals in 2050 Under the European Commission's Impact Assessment for the 2040 Climate Target



Note: The estimates are based on the S3 scenario in the impact assessment accompanying the Communication on the 2040 climate target from the European Commission. Most residual emissions from agriculture are from methane and nitrous oxide. Carbon removals from the LULUCF sector are generally not permanent.

In the S3 scenario, BioCCS and DACCS reach 33 Mt and 42 Mt of annual removals respectively in 2040.[11] An alternative scenario (S2) is able to reach an 88% reduction with 15 Mt of DACCS and 34 Mt of BioCCS. A review of the European Commission's modelling of permanent carbon removals deployment in various impact assessments over the past decade shows significant variation in results due to changes in core assumptions such as biomass availability.[12]

Possible pathways to a climate neutral EU have further been examined in the broad set of integrated assessment modelling (IAM) scenarios analysed by the European Scientific Advisory Board, which include between 390 and 1,165 Mt CO_2e of GHG emissions in 2050. In these scenarios, BECCS and DACCS deployment combined covers a range of 50-200 Mt/year by 2040, of which DACCS represents only between 0-7 Mt/year.

[11] Estimates from the S3 scenario in the impact assessment accompanying the 2040 climate target Communication from the European Commission.

[12] Böttcher & Fallasch (2024).

Permanent carbon removals in the EU are currently at a nascent stage, and the necessary policy framework to scale up these technologies is still largely lacking. The European Commission's framework for certifying permanent carbon removals, carbon farming and carbon storage in products (CRCF) and the Net-Zero Industry Act's EU-wide geological CO_2 storage target of 50 $MtCO_2$ per year by 2030[13] are steps in the right direction, but more comprehensive policies are needed to drive the deployment of permanent carbon removals in the EU. Despite the necessity of permanent carbon removals for meeting climate targets, scaling these technologies presents significant challenges. Many permanent carbon removal methods remain expensive and are not yet deployed at commercial scale, and both BioCCS and DACCS strongly depend on uncertain future availability of resources such as sustainable biomass and clean energy. This has led to a large level of uncertainty around the role of specific permanent carbon removal technologies in meeting the EU's climate targets. Furthermore, the scaling up of these technologies will also depend on the global deployment level, driven by investment and policies implemented outside the EU. Within this context, this report will focus on policies needed to ensure their sustainable deployment within the EU.

Integrating Permanent Carbon Removals into the EU ETS

Permanent carbon removal methods, including BioCCS and DACCS, currently sit outside of the EU's climate policy architecture. To ensure their sustainable deployment in the EU, the European Commission has been mandated to assess by 2026 if and how CO_2 which is removed from the atmosphere and safely and permanently stored could be accounted for and covered by emissions trading.

As a cornerstone of the EU's climate policy, the EU ETS is an effective tool to reduce energy and industrial emissions through a cap-and-trade system, and additional emitting sectors are set to be covered under the emissions trading system for buildings, road transport and additional sectors (EU ETS2) from 2027. Under the reform to ensure the system was 'Fit for 55' by 2030, the revised linear reduction factor for the existing 'EU ETS1' sectors is expected to reduce the cap on available emissions allowances (EUAs) significantly. Without changes to the emissions cap post-2030, the cap would reach close to zero by 2039, or by 2045 if aviation allowances are taken into account.[14] The emissions trajectory in the Commission's 2040 climate target modelling implies a more gradual reduction in the cap (see Figure 2). The tightening cap introduces new challenges, including the potential for high price volatility and inadequate liquidity in the market, often described as the 'endgame' of the EU ETS.[15] As allowances become scarcer, allowance prices could go above the cost of a permanent carbon removal.

Providing obligated entities with an alternative means to satisfy their EU ETS obligation through the purchase of 'carbon removal allowances' – representing one tonne of verified CO_2 removed from the atmosphere – has therefore been proposed as a means of maintaining market functionality, efficiency and liquidity. In theory, this would allow those sectors with marginal abatement costs in excess of the cost of permanent carbon removals to achieve net zero in the most cost-effective way. At the same time, creating demand for permanent carbon removals within such an established compliance market could increase demand for these technologies, as the sector currently depends on subsidies and voluntary demand for carbon removal credits.

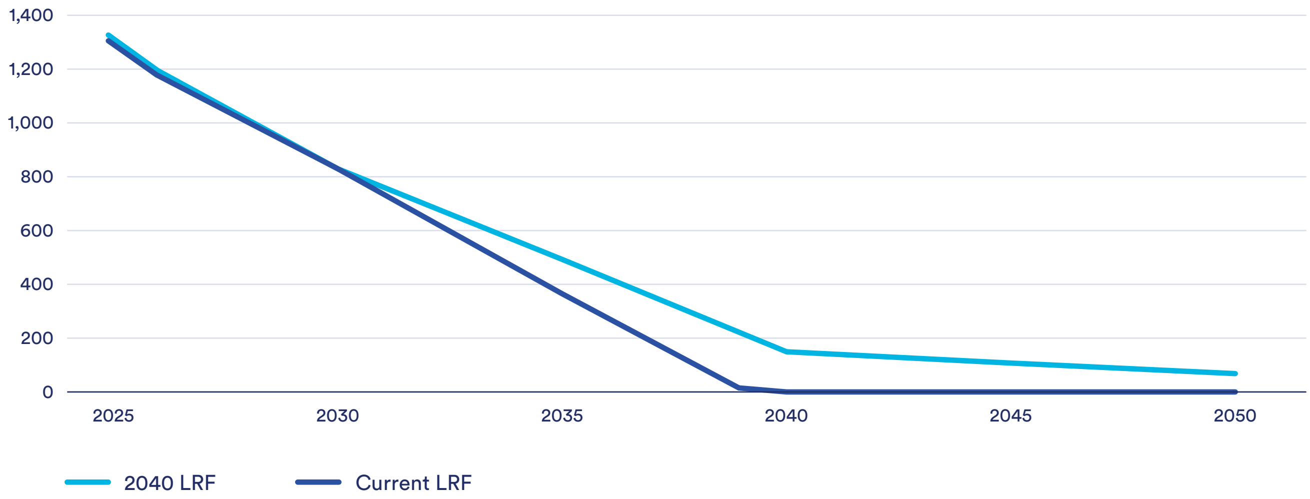
However, there are a number of possible approaches by which permanent carbon removals could be introduced into the EU ETS and, in addition to the potential benefits outlined here, several risks to consider. There remains a significant knowledge gap regarding the various options for integration and their associated risks and benefits. Some research has been carried out on the overall principles, but concrete details on implementation and safeguards against risks (e.g., the unsustainable use of certain biomass resources) are missing. As such, the report aims to explore the potential impacts on the functioning and integrity of the EU ETS as well as short and long-term demand for the deployment of permanent carbon removals.

[13] European Commission (2024c).

[14] While the emissions cap in Article 9 of the EU ETS Directive (stationary and maritime) would reach close to zero already in 2039 and zero in 2040, the allowances issued due to Article 3c (aviation) of the Directive are above 0 until 2044 and get to zero from 2045.

[15] Pahle et al. (2024).

Figure 2: The Emissions Cap under the Current Linear Reduction Factor or a Linear Reduction Factor Aligned with the European Commission's 2040 Climate Target Modelling



Note: The current linear reduction factor (LRF) is based on the emissions cap in Article 9 of the EU ETS Directive (stationary and maritime), and the 2040 LRF is based on an estimated trajectory of emissions for stationary, maritime, and aviation based on the European Commission's 2040 climate target modelling. The current LRF does not include allowances issued in respect of aviation.

1.2 Selection of Policy Options

The integration of permanent carbon removals into the EU ETS will require a range of decisions around safeguards and design features to ensure it meets the overarching goals of delivering on climate targets and provides long-term price signals and certainty for deployment of permanent carbon removals. To enable in-depth analysis that can provide valuable inputs, the focus of this report is limited to integration of permanent carbon removals into the existing EU ETS1.[16] The scope of this report has been narrowed down to analysing four different policy options (see Figure 3). The policy options are described in detail in Section 3.

Another policy option under consideration is the creation of a new and separate compliance market for carbon removals, i.e., a Removal Trading System, where covered entities are obliged to deliver or purchase an increasing volume of carbon removals.[17] One of the key arguments for keeping the emissions reduction and carbon removals markets separate is to avoid the risk of 'polluting' the EU ETS with different carbon removals, thereby keeping the reduction incentive under the EU ETS intact. Further, this approach could help drive a transition beyond climate neutrality to net-negative emissions.

While more research and conceptualisation of a separate compliance market for carbon removals is needed, this policy option will not be subject to detailed analyses in this report. The literature indicates that a separate compliance market for carbon removals can be designed in various ways, involving different regulated entities and obligation structures. Analysing this would require an assessment of multiple versions of the policy option and is not within the scope of this report. Reflections on how revenues from the EU ETS can possibly be used to provide funding for permanent carbon removals and how this interacts with the other policy options will be considered in the perspective section of the report.

16 EU ETS1 covers emissions from power and heat generation, energy-intensive industries (e.g., steel, cement, chemicals), and intra-European aviation.

17 For instance see Meyer-Ohlendorf (2023).

Figure 3: Assessment of Policy Options in the Report

1. Direct integration without restrictions
2. Direct integration with a maintained emissions cap
3. Direct integration with supply controls
4. Integration through an intermediary institution

The option to allocate free allowances to operators of permanent carbon removals is discarded as a viable policy option, since it is a transitional measure primarily used to address sectors at risk of carbon leakage.[18]

Evidence-based policy making requires exploration of all relevant options to ensure the chosen policy design is effective, fit for purpose, and aligns with the broader EU climate policy landscape. The report encourages further analysis of a separate compliance market as well as other methods to incentivise the deployment of permanent carbon removals to provide more insight into relevant policy options before taking a final decision on the regulation of permanent carbon removals in the EU.

1.3 Selection of Permanent Carbon Removal Methods

Carbon removals methods differ in permanence, additionality (relative to a counterfactual without the credited activity), measurability, and scalability. Given the importance of preserving the environmental integrity of the EU ETS, a high level of confidence in the permanence and measurability of carbon removals are key components to ensure the closest equivalent to emissions under the EU ETS. In the following, permanence, price, and monitoring, reporting, and verification are elaborated on to inform which permanent carbon removals could be considered for integration.

1.3.1 Permanence and Price

While natural carbon sinks have a risk of re-releasing CO_2 within climate-relevant timescales – through land-use change, fires, or other events – geological CO_2 sinks are regarded as 'permanent'.[19] BioCCS and DACCS are generally also easier to quantify, as the injection rate and subsurface behaviour of CO_2 can be accurately monitored, relative to natural carbon sinks.

The following set of principles have been proposed to determine whether an activity can be considered a permanent carbon removal:[20]

1. Physical CO_2 is removed from the atmosphere.
2. The removed CO_2 is stored out of the atmosphere in a manner intended to be permanent.
3. Upstream and downstream GHG emissions associated with the removal and storage process, such as biomass origin, energy use, gas fate, and co-product fate, are comprehensively estimated and included in the emission balance.
4. The total quantity of atmospheric greenhouse gases removed and permanently stored is greater than the total quantity of greenhouse gases emitted to the atmosphere.

Today, BioCCS and DACCS are relatively high-cost carbon removal methods. The separation of CO_2 from other gases is often an energy-intensive process, and the

[18] CONCITO (2022) has raised that the allocation of free allowances should be phased-out faster and better targeted.

[19] The 2005 IPCC Special Report on CCS determined that appropriately selected and managed geological reservoirs are likely to retain 99% of stored CO_2 over 1000 years, while leakage rates of up to 0.01%/year are considered not to significantly impact the climate value of the store.

[20] Tanzer and Ramirez (2019).

equipment required to collect and process large volumes of gas incurs high capital costs. These factors combine to make the capture of CO_2 from air particularly costly, with estimates for currently available **DACCS** technologies ranging from around 489 to 1313 EUR per tonne, depending on the capture technology used.[21] Estimates of potential technology learning and economies of scale suggest that costs could reduce to 320 EUR per tonne (liquid solvent) and 351 EUR per tonne (solid sorbent), when global deployment reaches gigatonne scales.[22]

BioCCS refers to a wide range of processes in which biogenic CO_2 arising from the combustion or industrial processing of biomass is captured and stored. Common examples of systems where biogenic CO_2 can be captured are the combustion of woody or waste biomass at energy production or waste treatment facilities, digestion of diverse feedstocks to produce biogas and biomethane, fermentation of sugar crops to ethanol, or the gasification of diverse feedstocks to produce synthetic fuels. As the concentration of CO_2 in the exhaust streams, the cost of biomass feedstock, and the operating hours vary significantly between processes, there is similar variation in the expected cost of BioCCS. For combustion-based processes, estimates for the cost per tonne of CO_2 removed generally fall in the range 150-250 EUR, while CO_2 captured from biogas plants delivers low costs in the range 50-150 EUR per tonne.[23] BioCCS processes can face highly variable costs for transporting CO_2 as – unlike DACCS – facilities may not be located in proximity to suitable geological storage sites.[24]

In its base analysis, this report will only consider integration of DACCS and specific forms of BioCCS, namely the capture and storage of biogenic CO_2 from biogas upgrading and from combustion-based processes. The term 'bioenergy with CCS' (BECCS) is used in this report to refer to CCS on combustion-based processes, which could include waste-to-energy plants or biomass-fired facilities for the production of heat and electricity. Another possible candidate method for integration is carbon storage in **biochar**: a highly carbon-rich solid material derived from the pyrolysis of biomass. The permanence of biochar is still being discussed and clarified and depends on the production process, the assessment methodology (e.g. assumptions on decay factors and inertinite fractions)[25] and the end use of the material (e.g. biochar applied in soils or in building materials like concrete and asphalt). Cost estimates for biochar generally fall in the range of 50 to 200 EUR per tonne of CO_2 removed depending on a wide range of factors such as the price of biomass feedstocks and demand for pyrolysis co-products (e.g. gas and oil). Biochar is included as a sensitivity case under the analysis of direct integration with no restrictions (Policy Option 1) to better understand the effects of its possible integration into the EU ETS in light of the utilisation of biomass resources and relatively low technology cost. Any integration of biochar would need additional measures on permanence and liability.

1.3.2 Robust Monitoring, Reporting, and Verification

Robust methodologies, including rules for monitoring, reporting, and verification (MRV), are essential for establishing standards that define high quality permanent carbon removals. DACCS, BioCCS and biochar can only deliver net carbon removals if the storage of CO_2 outweighs the emissions associated with the processes themselves. Quantification of the net tonnes removed is a key task for the methodologies developed under the CRCF. Currently draft methodologies are being assessed in the EU Expert Group on carbon removals.[26]

[21] Sievert et al. (2024). A lower current cost range (\$521-894/tCO_2) is attributed to liquid solvent technologies and a higher range (\$1180-1392/tCO_2) to solid sorbent technologies.

[22] Some DACCS technologies have reached a technology readiness level (TRL) of 8-9, with the world's largest plant (Climeworks' Mammoth plant in Iceland) capturing and storing 36,000 tCO_2/year, and Oxy's 500,000 tCO_2/year plant 'Stratos' expected to become operational in the USA from 2026. See Appendix 1 for further discussion of future costs.

[23] Abegg et al. (2024), Gentile et al. (2022), and Kubis et al. (2023). See Appendix 1 for a full review of costs.

[24] In the EU, early CCS projects are expected to face transport and storage costs of around €50-80/tCO_2, with the potential to fall to €20.

[25] According to Sanei et al. (2024), high-temperature pyrolysis yields biochar that is compositionally indistinguishable from pure inertinite maceral with a conservative half-life of 100 million years. From a policy perspective, this would make the inertinite part of biochar permanent making it more suitable for ETS integration. On the other hand, Woolf et al. (2021) and Azzi et al. (2024) assume that no fraction of the biochar is as stable as pure inertinite, and suggest that high quality biochar has a permanence of 82% to over 90% after 100 years, and between 74% to over 90% after 500 years, depending on the decay model used.

[26] European Commission (2024d).

The report has not analysed these draft methodologies, as they have yet to be finalised and adopted through delegated acts.

For **DACCS**, the need for robust carbon accounting is primarily linked to the carbon footprint of its significant energy consumption. Operation of the facilities may need to be coordinated with low-carbon energy generation that is additional to other grid demand. BioCCS and biochar present a more complex carbon accounting challenge, requiring consideration of the life cycle emissions associated with the fuel supply chain (transport and processing), as well as direct and indirect land use change effects and the counterfactual fate of the biomass feedstock. Waste biomass streams from existing economic activities (including agriculture, forestry, household waste) can offer more straight-forward carbon removal accounting, as they are not linked to land use change. However, the counterfactual fate of these wastes (e.g. natural decay) must still be addressed, as well as the risk of over-incentivising the production of waste through carbon removal crediting. The development of an EU certification methodology for BioCCS under the CRCF should provide appropriate incentives for BioCCS. While a new sustainability requirement for BioCCS facilities is introduced in the CRCF,[27] it is not expected that this alone would ensure a sustainable and prioritised BioCCS deployment in the EU.

Under the EU ETS, robust MRV would need to ensure that carbon removals provide a climate impact equivalent to the surrender of traditional EU ETS allowances. The CRCF methodologies for certifying a permanent carbon removal are based on life-cycle emissions, whereas the MRV in the EU ETS does not currently operate with life cycle calculations. Parts of the emissions of the life cycle assessment in the CRCF are covered by emissions trading (such as production of electricity for DACCS). On the other hand, CO_2 emissions from biomass are counted as zero under the EU ETS, if the feedstock and process comply with the sustainability criteria and GHG emission-saving criteria for the use of biomass.[28] This also relates to the future management and regulation of biomass use as elaborated in Section 4.1. In this light, **adjustments in the CRCF methodologies** could be needed if permanent carbon removals are integrated into the EU ETS. In parallel, the work on the IPCC's upcoming report on carbon removals and carbon capture utilisation and storage[29] could also have consequences for the MRV requirements regarding BioCCS, DACCS, and biochar.

Current emissions of biogenic CO_2 in the EU are estimated to be around 200 $MtCO_2$/year.[30] The accessible biogenic CO_2 potential for capture and storage is expected to be lower, when factoring in sustainability aspects (e.g. cost and competition on biomass resources) and other factors (e.g. capture rates, limited operating hours, installation size, transport barriers etc.). Ultimately, the availability of BioCCS in the EU and globally is expected to be constrained by the limited supply of biomass that can deliver net carbon removals without negative impacts on food production, water availability and other socio-economic priorities. The IPCC and the International Energy Agency (IEA) estimate that global availability of sustainable biomass will likely be limited to around 100 EJ/year in 2050; the EU's current consumption of biomass for bioenergy purposes (5.6 EJ/year) is already equivalent to this rate on a per capita basis.[31] In addition, carbon capture and utilisation (CCU), such as for the production of sustainable aviation fuels, will likely further increase demand and compete for the limited supply of biogenic CO_2.

The report also excludes other carbon removal methods from its scope such as **enhanced rock weathering and ocean alkalinization** due to uncertainties around MRV and other implementation effects, which will require further research before they can be considered covered by emissions trading.

27 These facilities will need to demonstrate that, as a result of the financial benefits related to the CRCF certification, their total energy capacity has not increased beyond what is necessary for operating carbon capture and storage.

28 Rules from Directive (EU) 2018/2001.

29 IPCC (2024).

30 ERM (2022); CONCITO (2023).

31 CONCITO (2023).

SECTION 2

Assessment Criteria and Methods

2.1 Assessment Criteria to Evaluate Policy Options

The report has developed assessment criteria with a focus on environmental integrity and effectiveness to evaluate the different policy options. Each criteria is based upon indicators covering different types of impacts to be considered. Some of the indicators are affected differently in the short and long term, which will be reflected in the analysis to the greatest extent possible. An overview of the assessment criteria and corresponding indicators are provided in Table 1.[32]

Other aspects, such as the political dynamics, social acceptance, and sectoral competitiveness will not be considered in the analysis. Reflections on the aspects of environmental integrity related to the durability, risk of reversal, and measurability of different carbon removals are included in the selection of permanent carbon removal methods above and are therefore not a separate assessment criteria in the analysis. When assessing the various options' policy coherence, other objectives than EU climate targets, such as biodiversity targets and objectives, are not included. Furthermore, each policy option will need to take account of and adapt to future changes to both the EU ETS and the broader policy mix, which is explored in the final section of the report.

The assessments of the policy options will be summarised by colour coding the indicators, based on professional judgement. Green signifies that the option will potentially have mostly positive impacts for that particular indicator, while red indicates mostly negative impacts, and gray indicates both positive and negative impacts. The land sector risk assessment is likely sensitive to the biomass resource used, as some biomass resources serve as durable carbon sinks in the land sector and provide biodiversity and food, while other biomass resources may be responsible for emissions or harm the environment if not managed. This metric should be further explored in future work.

[32] The indicators are not listed in order of priority.

Table 1: Assessment Criteria and Indicators

Criteria	Indicators	Description
Incentive for permanent carbon removals	Deployment of permanent carbon removals	Interventions should create appropriate demand for deployment of high-quality permanent carbon removals in line with EU climate targets.
Maintain incentive for emissions reduction	Abatement deterrence	Interventions should address risks of abatement deterrence (often referred to as "mitigation deterrence" elsewhere in public debates and literature). Abatement deterrence is understood as the prospects of reduced or delayed emissions reductions due to the introduction or expectation of carbon removals, i.e. when carbon removals substitute for otherwise expected emissions reductions.[33]
Cost-effectiveness	Mitigation at lowest economic cost	Integration should work towards establishing a framework that ensures a cost-effective mix between reducing emissions and using permanent carbon removals, enabling compliance entities to achieve abatement at the lowest cost to meet climate targets.
Market functioning[34]	Volatility	Interventions should consider the effects on volatility. Volatility in allowance prices is not necessarily a negative outcome,[35] but high volatility can be undesirable for compliance entities, as they need a reliable price signal on which to base long-term investment decisions.
	Liquidity	Interventions should take into account market liquidity, i.e. traded volumes, since a liquid market can improve market functioning.[36]
Sustainability	Land sector risks	Interventions should be designed to take into account associated risks for climate (potential negative impact on land carbon sinks) and the environment (biodiversity and food production through direct and indirect land use change) of biomass resource use for BioCCS and possibly biochar. The main issue is the current lack of pricing of environmental externalities in the land use sector potentially leading to arbitrage.[38]
Implementability	Administrative costs	Interventions should aim to limit additional administrative complexity and burdens on regulated entities and regulators.
	Speed/ease of implementation	Interventions should consider speed/ease of implementation such that it is operationally feasible in timescales relevant for EU climate targets.
	Fiscal impact	Interventions should maximise the value of auctioning revenues and take into account impacts on distribution of revenues (e.g. among Member States and EU funds).
Policy coherence	Deliverability of a net-zero and net-negative EU	Interventions should be coherent with EU climate targets of reaching climate neutrality and net-negative emissions hereafter.

33 Its root cause is the long-term uncertainty of permanent carbon removals (e.g. limited/incomplete information on future costs and availability of BioCCS, DACCS, and biochar), and the risk of crowding out emission reduction efforts by perpetuating fossil infrastructures.

34 This assessment criteria will not look into order aspects of market quality such as price discovery, market participation, opportunities of market abuse etc., since they are not expected to differ for the various policy options.

35 In an efficient market, prices would be expected to vary in response to new information. Some traders and financial participants may be more positive to volatility because it creates trading opportunities.

36 A liquid market allows market participants to open and close positions – in other words, enter and exit the market – whenever they want. This could e.g. be affected if an intervention reduces the opportunity for trading allowances.

37 Other issues related to sustainability and land sector risks such as social risks and spillover effects of the EU's biomass use in countries outside the EU are not included directly in the report.

38 Sultani et al. (2024).

2.2 Quantitative and Qualitative Insights to Evaluate Policy Options

Both quantitative and qualitative insights are used to evaluate the four policy options against the assessment criteria.

The **quantitative assessment** is based on a simple and static numerical modelling using marginal abatement cost (MAC) curves and technology price paths for permanent carbon removals. The results are based on the scope of the EU ETS1 and do not include the impact of potential scope expansion to energy from waste and non-permanent CCU. The possibility to integrate permanent carbon removals in the emissions trading system for road transport, buildings and additional sectors (EU ETS2) or a possible future agricultural emissions trading system are not quantified but are reflected upon in the last section of the report.

The results presented are scenario-based estimates rather than forecasts and are not weighted by likelihoods. The modelling involves several assumptions, such as technology costs/limitations, the future emissions cap, the development of the allowance price, other financial incentives (public funding and support from voluntary carbon markets), and has several limitations elaborated in Appendix 1. In the modelling, an unchanged application of the current linear reduction factor (LRF) post-2030 is not assumed. Following this, it is not assumed the overall emissions cap in the EU ETS approaches zero in 2039. Instead, the model is based on the trajectory of emissions in the European Commission's 2040 climate target modelling.[39] To show the implications of different LRF assumptions, a sensitivity analysis, where it is assumed that the emissions cap reaches close to zero around 2039, is performed in Appendix 2. Politically, it has not yet been decided if and when permanent carbon removals would be integrated into the EU ETS. In the analysis, 2030 is assumed as the earliest possible date for integration in light of possible political negotiations after a potential legislative proposal post-2026 followed by an implementation period.

While the modelling can provide valuable indications of the direction and size of impacts, the real-world deployment of permanent carbon removals is more difficult to capture.[40] In this light, the modelling will only be used partly to evaluate the assessment criteria on incentive for permanent carbon removals, maintaining emissions reductions, sustainability, and policy coherence, and care will be taken in interpreting the results. To understand how changes in the assumptions, e.g. changes to the marginal abatement costs and technology costs, affect the results, sensitivity analysis have been carried out in Appendix 2.

The report uses **qualitative sources** to evaluate all the policy options against the assessment criteria. This takes into account the growing literature and research on the topic and experiences with integrating carbon removals in the emission trading systems in countries outside the EU. A project advisory group with representatives from academia, NGOs, and business have also provided informal feedback and inputs on the content of the report to improve and refine quality and policy relevance.

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39 Without a change to the current linear reduction factor (LRF), it would reach close to zero already in 2039 and zero in 2040 (with aviation and banked allowances it gets to zero in 2045). However, in the 2040 target impact assessment, the Commission assumes the EU ETS will be reviewed in view of being compliant with the 2040 climate target. Consequently, their analysis does not by default assume a prolonged unchanged application of the LRF post-2030.

40 E.g. care must be taken in interpreting marginal abatement cost (MAC) curves, as MAC curves often present maximum technical potential (i.e., full implementation of BioCCS, DACCS, and biochar), and fail to adequately recognise non-financial barriers and capture full costs of implementing actions for operators of permanent carbon removals.

SECTION 3

Analysis

3.1 Direct Integration into the EU ETS (Policy Option 1)

Description of Policy Option

The first policy option subject to analysis is direct integration of permanent carbon removals into the existing EU ETS without restrictions. This option would allow an unlimited quantity of permanent carbon removal allowances into the EU ETS to be used for compliance obligations in addition to traditional EU Allowances (EUAs). This option has also been addressed quite extensively in the literature.[41]

In practice, it would involve granting a carbon removal operator one allowance for each tonne of CO_2 they capture and permanently store. Traditional EUAs and allowances granted to permanent carbon removal operators would have full fungibility, i.e. the same compliance value, each permitting obligated entities to emit 1 tonne of CO_2e. Assumptions on specific **allowance design and route to market (auctioning set-up)** are considered in the analysis.

It is assumed throughout the analysis that the allowances for permanent carbon removals will be issued to operators after the carbon removal has taken place and been verified (ex-post). An **ex-post allowance distribution** prevents premature crediting, which could undermine the environmental integrity of the EU ETS. This approach also guarantees that the operator is motivated to complete the entire value chain either directly or through contracting other entities.

According to the CRCF,[42] any geological storage of CO_2 must be carried out in countries which are covered by the CCS Directive.[43] From this, the report assumes that any integration of permanent carbon removals into the

41 E.g. Sultani et al. (2024), UK ETS authority (2024), Ecologic Institute (2023), Oxera (2022), Burke & Gambhir (2022), ICAP (2021), and Rickels et al. (2021).

42 When reviewing the regulation, the European Commission will consider the possibility of allowing geological carbon storage in neighbouring third countries, if equivalent conditions to those laid out in the CCS Directive are provided to ensure permanently secure and environmentally safe geological storage of captured CO_2.

43 Directive 2009/31/EC.

EU ETS will follow a similar logic. The analysis does not include internationally provided carbon removals. Allowing international carbon removals to access the EU ETS could have broad and significant implications for the functioning and environmental integrity of the system.

Assessment of Policy Option

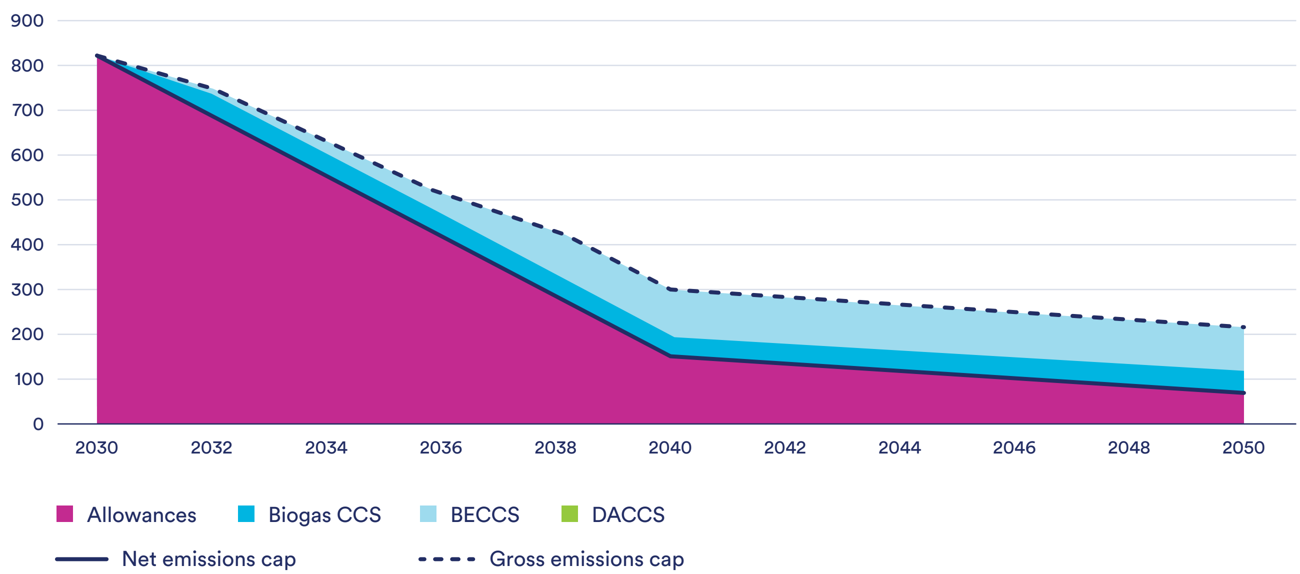
Incentive for Permanent Carbon Removals

The creation of **sufficient incentives for permanent carbon removals** to drive deployment through direct integration depends on the expected and realised difference between the allowance price and the cost of permanent carbon removals. Direct integration will likely create some incentives for permanent carbon removals as soon as the integration is politically agreed upon and announced, since it strengthens the business case for carbon removals by signalling future demand. If the allowance price surpasses the costs of permanent carbon removal technologies, it becomes profitable to generate and sell permanent carbon removal allowances into the EU ETS. The higher the realised allowance price, the more applications of permanent carbon removal technologies become profitable and the stronger the incentive becomes.

Direct integration without restrictions could potentially finance an extensive deployment of permanent carbon removals as there is no limit on the quantity of carbon removal allowances allowed to enter the system. However, as these carbon removals enter the system, the allowance price will be affected. In this scenario, the total number of allowances in the system increases (i.e. the gross emissions cap[44] increases as illustrated in Figure 4). This is expected to have a dampening effect on allowance prices in the EU ETS, potentially causing the price to stagnate, thus hampering the incentive for permanent carbon removals.

Figure 4 presents a stylised modelling of how direct integration without restrictions could impact the gross emissions cap in the EU ETS. The figure indicates that direct integration incentivises deployment of the

Figure 4: Emissions Cap under Direct Integration without Restrictions



Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050 without restrictions. 'Net emissions cap' refers to the number of traditional emission allowances (EUAs) in the EU ETS, while 'gross emissions cap' refers to the total number of EUAs and carbon removal allowances in the market. As described in Appendix 1, the maximum removal capacity is limited at 50 million tonnes per year for biogas CCS (carbon capture and storage on upgrading of biogas) and 100 million tonnes per year for BECCS (bioenergy with carbon capture and storage). There is no assumed quantity limit on DACCS.

[44] The EU ETS Gross Cap = Number of traditional EUAs + Number of permanent carbon removal allowances.

cheapest carbon removal technologies first. This is true for any direct integration (i.e. Policy Options 1, 2, and 3). The results indicate that allowances granted to CCS on biogas upgrading start entering the system in the early 2030s. BECCS will likely enter the system on a larger scale throughout the 2030s, with the model indicating that both technologies could potentially see significant deployment before 2040. On the deployment of DACCS, however, the results suggest that the allowance price never reaches a high enough level for DACCS to be viable towards 2050. Assuming lower DACCS costs (falling from 335 EUR per tonne to 250 EUR per tonne), the system could see a modest inflow of DACCS-based allowances in the 2040s as shown in a sensitivity analysis (see Figure A5 in Appendix 2).

The results highlight that direct integration in the EU ETS alone may not provide sufficient incentives for permanent carbon removals. As demonstrated in a sensitivity analysis in Appendix 2, permanent carbon removals enter the EU ETS at a significantly later date if the allowance price is assumed to be lower (see Figure A3 in Appendix 2). This underlines the importance of potential supporting policies that bridge the gap between the allowance price and cost of permanent carbon removals in the short to medium term. Furthermore, the deployment of permanent carbon removals could be significantly affected by the setting of the emissions cap. If the current linear reduction factor in the EU ETS is continued post-2030, the deployment of permanent carbon removals would be higher than indicated in Figure 4 due to higher scarcity of traditional emissions allowances and therefore higher allowance prices (see Figure A2 in Appendix 2).

Finally, if **biochar** is integrated alongside BioCCS and DACCS, the modelling indicates that carbon removal allowances from biochar could enter the system quite extensively due to its relatively low technology cost (see Figure A4 in Appendix 2). In addition, modelling results indicate that because biochar often is cheaper than BECCS, biochar deployment could potentially crowd out some BECCS deployment if both are sourcing their biogenic feedstocks from the same limited pool of biomass resources in the EU. Whether biochar crowds out BECCS rather than coming in alongside BECCS depends on how many of the same biogenic resources biochar and BECCS are competing for (e.g woody or agricultural biomass resources). The analysis does not take into account additional imports of biomass from outside the EU, which could lead to higher deployment of both biochar and BECCS, but introduces additional sustainability risks.

Incentive for Emissions Reduction

While one of the purposes of integrating permanent carbon removals into the EU ETS would be to support demand for these types of carbon removals, it is essential for the integrity of EU climate policies to **maintain the incentive for emissions reductions**. With a direct integration without restrictions, the gross emissions cap in the EU ETS increases as carbon removal allowances enter the system (as illustrated in Figure 4), allowing regulated entities under the EU ETS to emit more by substituting reductions with carbon removals. This leads to so-called abatement deterrence, where EU ETS gross emissions increase (beyond the politically agreed trajectory of the EU ETS emissions cap) relative to a counterfactual of no integration of permanent carbon removals.[45]

Our analysis shows that this policy option entails a high risk of deterrence of emissions reductions, since it does not limit the inflow of permanent carbon removals into the system, allowing gross emissions to continue to increase as long as incentives for carbon removals are sustained. The absence of restrictions means policymakers, to a certain extent, lose the ability to control the overall trajectory of emission reductions within the EU ETS. The magnitude of abatement deterrence depends on how many carbon removals enter the EU ETS, which is uncertain. If large volumes enter the system, causing the gross emissions cap to increase significantly and allowances prices to stagnate, this could prompt reactions among policymakers and have political implications. However, the political dynamics are not subject to further analysis.

Experiences from New Zealand highlight the risk to sustained emissions reductions from directly integrating carbon removals without safeguards (see Box 1). As such, direct integration without restrictions risks leading to **a high degree of abatement deterrence**. Given the uncertainties and possible lower cost of **biochar**, the risks of deterring emissions reductions could be amplified by integrating this technology.

[45] Abatement deterrence comes with certain risks, such as a hold-up problem (e.g. see Sultani et al (2024)), where firms in the EU ETS delay reduction efforts until they have more clarity on carbon removal costs, leading to firms purchasing more EUAs, causing allowance prices to increase. This could prompt a loosening of the cap if prices exceed politically acceptable limits, compromising the environmental integrity of the EU ETS.

Box 1: The New Zealand Emissions Trading Scheme (NZ ETS)

While this report focuses solely on permanent carbon removals, important lessons can be drawn from New Zealand's experience with directly integrating nature-based carbon removals into the NZ ETS without restrictions. The NZ ETS allows forest credits to enter the system, meaning forestry NZ ETS participants can earn New Zealand Units (NZUs) based on the amount of carbon absorbed by the forest. The NZ ETS treats emissions reductions and carbon removals similarly: 1 tonne of emissions reductions is equivalent to 1 tonne of carbon removals.

Similar to integration of permanent carbon removals into the EU ETS, the NZ ETS couples the price of emissions and carbon removals, which drives investments in the lowest-cost abatement option first. With unrestricted integration, this means large quantities of cheap carbon removals could enter the NZ ETS, causing carbon prices to drop and the risk of abatement deterrence to increase.

A review from June 2023 by the former New Zealand Government suggests the design of the NZ ETS does not align with the decision to prioritise emissions reductions in climate efforts.[46] The review predicts a high supply of forestry carbon removals into the system, allowing emitters to meet all or most of their NZ ETS obligations at a relatively low cost and avoiding more expensive emission reduction efforts. The review predicts the NZU supply from forests is likely to exceed demand from emitters, leading to plummeting NZU prices from around 80 $/NZU in 2022 to less than 40 $/NZU by 2040 and falling to just above 35 $/NZU around 2050. This will lower the ability of the NZ ETS to drive significant emissions reductions and incentivise more expensive carbon removals. The overreliance on cheap nature-based carbon removals risks delaying and deterring climate action in New Zealand.

Cost-effectiveness

Direct integration into the EU ETS has been characterised as the first-best vision[47] for a long-term policy that ensures economically desirable and **cost-effective mitigation**. By integrating permanent carbon removals directly into the EU ETS, the price of permanent carbon removals and emissions are directly linked. This lowers the financial burdens for companies in the EU ETS as permanent carbon removals could offer a cheaper alternative to higher-cost abatement measures. At the same time, payments for permanent carbon removals are constrained by the allowance price, ensuring a cost-effective deployment. Including **biochar** could possibly bring down mitigation costs for participants even further due to the relatively lower technology costs.

The exact effects on cost-effectiveness would in practice also depend on the decisions around **allowance design and auctioning set-up** (applies for Policy Option 1, 2 and 3). Rather than assuming that operators of permanent carbon removal activities are rewarded with traditional EU Allowances (EUAs), and that these allowances are then available for purchase from normal auctions or on secondary markets, another option is to differentiate between traditional EUAs and allowances generated by permanent carbon removals and facilitate separate auctions for them. This would not impact how allowances from permanent carbon removals can be used for compliance purposes, but would enhance information on the levels of demand and prices of different permanent carbon removals methods to inform market participants and policymakers.

46 Ministry for the Environment, Ministry for Primary Industries and Ministry of Business, Innovation & Employment (2023).

47 E.g. Sultani et al. (2024).

Further, differentiated allowances could potentially support price discovery on the market. Separate allowance designs and auctions for traditional EUAs and permanent carbon removals could demonstrate if market participants are willing to pay more for allowances from permanent carbon removals, e.g. for non-compliance reasons, which potentially could lead to different allowances prices.[48] Some EU regulations (such as the Green Claims Directive) could impact firms' willingness to pay for carbon removal allowances, since it could restrict their ability to use carbon removals for claiming purposes. If operators of permanent carbon removals activities could attract a higher price, this could enable greater access to finance and, some argue,[49] a more cost-effective deployment. It is uncertain whether a higher willingness to pay for carbon removals would materialise.

Market Functioning

A direct integration could also impact the **market functioning of the EU ETS**. Integrating permanent carbon removals into the EU ETS will **increase liquidity** by increasing the volume of allowances. This would increase the ability to trade quantities of allowances and thereby contribute to the functioning of the system as the net emission cap approaches zero.[50] Decisions on allowance design and route to market (auctioning set-up) could also possibly impact liquidity. For instance, if separate auctions are established for carbon removal allowances and traditional EUAs, it would create two types of allowances. Separating the market in this manner could limit trading opportunities and therefore possibly result in lower liquidity.

Direct integration could have **positive and negative impacts on price volatility**, as market participants would need to accurately assess future availability and costs of permanent carbon removals. Currently, the technological uncertainty of permanent carbon removals makes it difficult to predict these factors reliably. Linking the quantity of emissions to the expectation of permanent carbon removals could thus risk adding uncertainty and volatility to the system in the short term. In the longer term, when technological and deployment uncertainty decreases, an integration might be one of several policy decisions that provides a stabilising supply of allowances that increases liquidity, thus mitigating market volatility as the emissions cap decreases. Given the uncertainties regarding the availability and cost of **biochar**, the positive impact on liquidity and positive/negative impact on price volatility could be amplified by integrating the technology without restrictions.

Sustainability

As illustrated in Figure 4, direct integration could potentially lead to high deployment of BioCCS and no deployment of DACCS, if relying solely on price signals from the EU ETS. The deployment of BioCCS indicated by the modelling results is significantly higher than the European Commission's own modelling to reach a 90% climate target by 2040, where BioCCS deployment reaches 33 Mt CO_2 in 2040 and 56 Mt in 2050 due to a cap on biomass availability[51] and the use of biogenic CO_2 for CCU. The incentive for such high volumes is also affected by the 'zero rating' of biogenic emissions from 'sustainable'[52] biomass use in the EU ETS. High levels of BioCCS deployment comes with the risk of a negative impact on sustainability due to an assumed unsustainably high use of biomass use.[53] Currently, there is a lack of pricing of environmental externalities in the land use sector,[54] which may result in arbitrage, and negatively impact biodiversity and/or carbon sinks in the LULUCF sector depending on the biomass resources. Implementing financial incentives for BioCCS through EU ETS integration could exacerbate the existing imbalance

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48 The UK ETS authority points to the fact that in the voluntary market, buyers are willing to pay more than the UK ETS carbon price for permanent carbon removals.

49 E.g. UK ETS authority (2024).

50 As emissions approach zero and the number of market players shrinks, issues of market liquidity and uneven market power could become a problem under the EU ETS.

51 Based on the environmental risk level indicated by the European Scientific Advisory Board on Climate Change (ESABCC), the Commission applies an overall cap on the gross available energy from biomass at 9 EJ. Additionally, based on scientific literature related to biodiversity and sustainable wood biomass use, restrictions are applied to the use of harvestable stemwood (30 Mtoe), forest residues (20 Mtoe), and imports of bioenergy (10 Mtoe).

52 If the biomass feedstock and process comply with the sustainability criteria and GHG emission-saving criteria for the use of biomass.

53 The lack of pricing of externalities (incl. GHG emissions) in the land use sector can lead to sectoral leakage effects and distortion through inefficient use of biomass.

54 Sultani et al. (2024).

between incentives for biomass combustion (e.g. the zero rating of most biogenic emissions) and the LULUCF carbon sink for certain biomass resources. A high level of BioCCS deployment might require access to additional land due to the biomass use, which could have negative impacts on the environment (e.g. biodiversity) and food security in light of the increasing and competing demands for biomass in the EU.[55] Considering the fact that **biochar** production will also utilise biomass resources, this risk could be even greater if biochar is integrated into the EU ETS. Biochar would have an even larger impact on land use change and food production if the additional biomass feedstocks for this production comes from areas where no substitution (e.g. decrease of biomass use in other industries or sectors) is taking place. Sustainability outcomes will be influenced by the types of biomass resources used for BioCCS and this should be explored in more detail in future work.

Implementability

Implementing this policy option will require several design elements which are common to most approaches for integrating permanent carbon removals. As described in Section 1.3, the regulator should assess whether adjustments are needed to the methodologies under the CRCF. If **biochar** is decided to be integrated, specific measures addressing permanence, e.g. fungibility measures (e.g. buffer pools and equivalence ratio), would need to be carefully considered and assessed. Furthermore, an update of delivery systems (e.g. the Union Registry)[56] would need to be implemented. The potential set-up of separated auctions could affect the speed of implementation, but it is expected that they could be established in parallel with other design elements.

Compared to other integration options, a direct integration would potentially be more easily implemented. Integration would add little complexity or **administrative costs** for emitting entities in the EU ETS, since carbon removal allowances will have the same compliance value as traditional EUAs and can be readily purchased on auctions or the secondary market. While limited, there will be an administrative cost for operators of permanent carbon removal activities associated with separate MRV and the sale of allowances at auctions or into the secondary market. For the regulator, there would be increased administrative costs associated with setting up the different design elements and oversight, although the regulator would not directly have a role of purchasing and/or procuring permanent carbon removals under the EU ETS.

Integration without restrictions of permanent carbon removals into the EU ETS would have **fiscal impacts** in the sense that auctioning revenues for Member States could decrease compared to no integration due to the price stagnation effect, as carbon removal allowances increase the overall allowance supply. For some Member States, this impact on revenues could be mitigated by reducing other public funding for permanent carbon removals.[57]

Another financial consideration is the price paid to permanent carbon removal operators. If an operator of CCS on biogas upgrading incurs carbon removal costs of 75 EUR per tonne but can sell their allowances at 150 EUR per tonne, they could gain potentially large profits (referred to here as '**excessive profits**'). From a purely economic point of view, this does not necessarily constitute a problem,[58] and some could argue that the prospects of large profits help drive innovation and deployment. However, from a fiscal perspective, it may be considered an issue by policymakers. Allowing operators to charge well above their carbon removal costs may inadvertently divert revenues away from Member States and EU funds. Prospects of excessive profits would be even greater, if biochar is integrated into the EU ETS due to its relatively low costs. The price stagnation effect as permanent carbon removals enter the EU ETS could mitigate excessive profits to some extent depending on the volume and costs of carbon removal allowances entering the system.

55 EEA (2023).

56 The European Commission points to the consideration of the technical elements of different integration approaches, such as if certificates would need to be exchanged for certificates in the Union Registry, or if certificates can be directly accepted in the Union Registry instead, and the connection to the registry for carbon removals.

57 E.g., the Danish NECCS Fund introduced a 'clawback mechanism', so the possible subsidy for companies delivering negative emissions would be lowered in the case of an EU ETS integration.

58 The difference between the allowance and the marginal cost is known as the inframarginal rent.

Policy Coherence

This policy option could at a maximum bring sectors under the existing EU ETS to net zero, since demand for neutralising residual emissions within these sectors with permanent carbon removals could materialise. In this sense, integration could contribute to the goal of economy-wide climate neutrality by 2050 at the latest, but not in itself balance all residual emissions (e.g. in agriculture) with carbon removals. This would depend on the broader evolution of emissions trading in the EU (e.g. extension to other sectors, allowing permanent carbon removals in the EU ETS2 and/or emissions trading in agriculture etc.). The policy option in itself would not be sufficient to deliver net-negative emissions after 2050, unless a net-negative emissions cap is designed with additional obligations, since the demand for permanent carbon removals would not be sufficient. Additional policies and measures would need to be put in place for net-negative emissions (see Section 4.1).

Findings

The colour-coded indicators below summarise the findings from the analysis of policy option 1. Green signifies that the option will potentially have mostly positive impacts for that particular indicator, while red indicates mostly negative impacts, and gray indicates both positive and negative impacts.

Criteria	Indicators	Impact
Incentive for permanent carbon removals	Deployment of permanent carbon removals	**Both positive and negative impacts**
Incentive for emissions reduction	Risk of abatement deterrence	**Negative impacts**
Cost-effectiveness	Cost-effectiveness	**Positive impacts**
Market functioning	Volatility	**Both positive and negative impacts**
	Liquidity	**Positive impacts**
Sustainability	Land sector risks	**Negative impacts**
Implementability	Administrative costs	**Both positive and negative impacts**
	Speed/ease of implementation	**Both positive and negative impacts**
	Fiscal impacts	**Both positive and negative impacts**
Policy coherence	Deliverability of net-zero and net-negative	**Both positive and negative impacts**

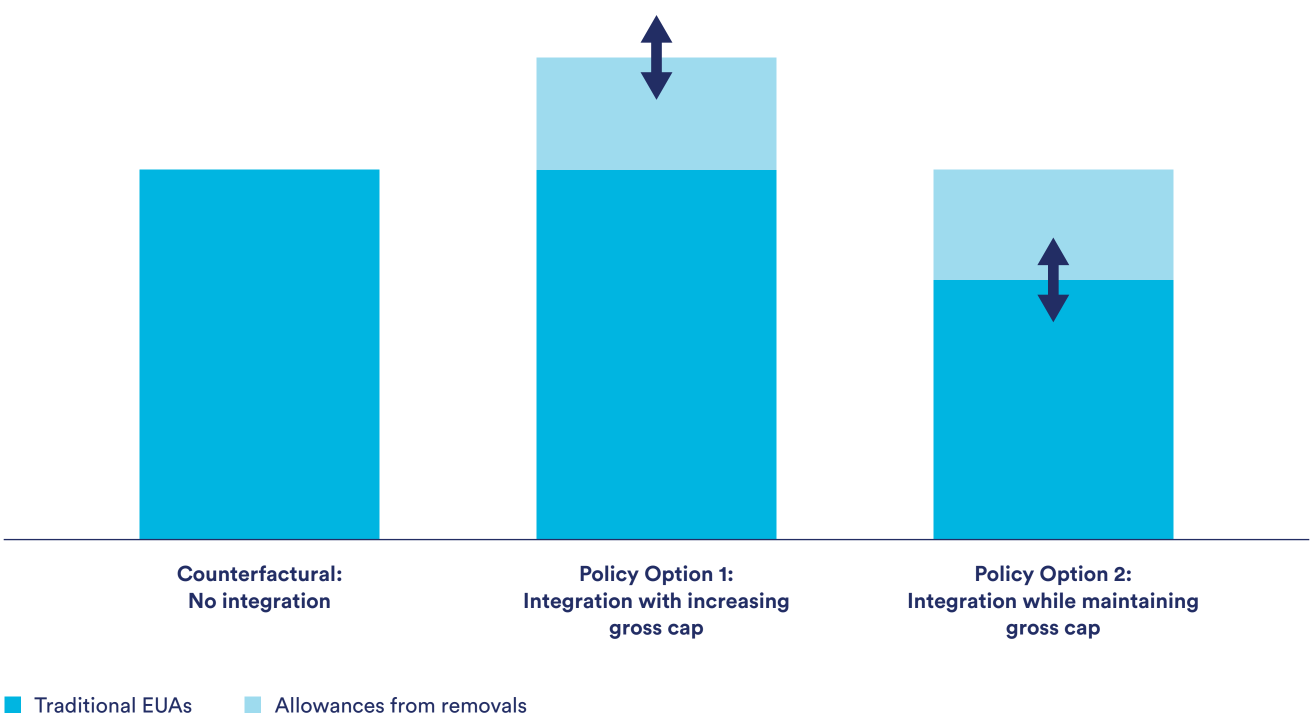
3.2 Direct Integration into the EU ETS with a Maintained Emissions Cap (Policy Option 2)

Description of Policy Option

As shown in the analysis above, a direct integration of permanent carbon removals without restrictions into the EU ETS comes with significant risks. In order to take into account some of these risks and safeguard incentives for emission reductions, one policy option is to make adjustments to the emissions cap as allowances from permanent carbon removals enter the market. This option has been explored to a limited extent in current documents and publications.[59]

Several options for adjusting the emissions cap exist.[60] In the following analysis, the option of maintaining the overall supply of allowances (gross emissions cap) at the same level is assessed. This means that for each permanent carbon removal allowance entering the EU ETS, one fewer traditional EUA is released at auction, as illustrated in Figure 5 below.

Figure 5: The Gross Emissions Cap in Policy Options 1 and 2



Note: The figure is inspired by the UK ETS authority, and for illustrative purposes only, i.e. the bars are not to scale. The arrows show uncertainty around supply of carbon removal allowances. In the counterfactual, where permanent carbon removals are not integrated into the EU ETS, there are no changes to the supply of allowances in the EU ETS. The first policy option allows the gross cap to increase, meaning carbon removal allowances come on top of traditional EUAs, increasing the gross cap. Policy Option 2 maintains the gross cap, and reduces the amount of traditional EUAs as allowances from carbon removals replace traditional EUAs.

59 UK ETS authority (2024).

60 E.g. set a new lower emissions cap but do not apply this to the permanent carbon removals. Here, the allowances issued to permanent carbon removal operators would then enter the market in addition to the supply of allowances set out by this new cap.

Assessment of Policy Option

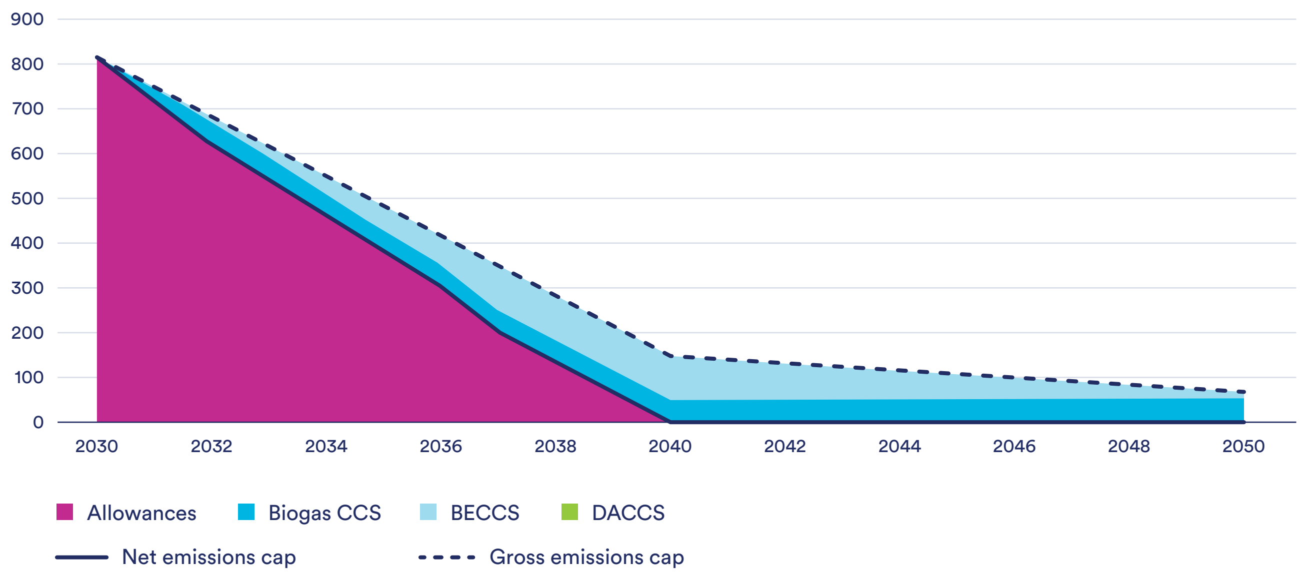
Incentive for Permanent Carbon Removals

An adjusted cap could have both positive and negative impacts on creating **incentives for permanent carbon removals**.

In the short run, permanent carbon removal operators would benefit from a relatively stronger demand signal due to higher carbon prices compared to direct integration without restrictions (Policy Option 1). Rather than allowing the gross cap to rise and allowance prices to fall, there will be no impact on the allowance price if the gross emissions cap is maintained.[61]

As shown in Figure 6, the modelling results indicate that allowances from CCS on biogas upgrading enter the system from the first years of integration. The subsequent deployment of BECCS would likely occur earlier than under Policy Option 1 due to a stronger allowance price signal. However, the model still indicates that DACCS deployment would only occur with additional financial incentives (e.g. public funding and/or contributions from the voluntary carbon market). As with Policy Option 1, it is important to stress that the ability of the EU ETS to incentivise deployment of permanent carbon removals strongly depends on the allowance price, and that the EU ETS alone might be insufficient in providing the necessary incentive for deployment of permanent carbon removals if future allowance prices are not significantly higher than today's level.

Figure 6: Emissions Cap under Direct Integration with a Maintained Emissions Cap



Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050 while maintaining the emissions cap. As described in Appendix 1, the removal capacity is limited at 50 million tonnes per year for biogas CCS (carbon capture and storage on upgrading of biogas) and 100 million tonnes per year for BECCS (bioenergy with carbon capture and storage) in the modelling. There is no assumed quantity limit on DACCS.

61 Since emissions allowances and allowances for permanent carbon removals have the same value for compliance purposes.

In the long run, the supply of permanent carbon removals could exceed their demand since the gross emissions cap could fall below the level of permanent carbon removals available for auctioning. Consequently, some carbon removals are not allowed to enter the market since for each carbon removal entering the market, one traditional allowance must be deducted from auctioning. As such, in the longer term, a continuously strong incentive for permanent carbon removals could necessitate adjustments to the safeguard and/or additional policies that can sustain demand. For instance, revising the cap and allowing allowances from permanent carbon removals to enter the market in addition to traditional EUAs, as is being considered in the UK (see Box 2), or setting a new higher gross emissions cap with continued deduction of traditional EUAs would create additional demand. These elements are elaborated in Section 3.5 and 4.1.

Incentive for Emissions Reduction

Maintaining the gross cap effectively prevents abatement deterrence and **preserves the incentive to reduce emissions**. Incentives to decarbonise remain intact as permanent carbon removals come in addition to rather than substituting emissions reduction efforts. Uncertainty about the supply of permanent carbon removals will not affect EU ETS outcomes. If permanent carbon removals do not live up to expected availability or declining cost curves, it will not directly affect abatement efforts within the EU ETS due to the maintained gross cap. Addressing potential abatement deterrence is the main driver behind the UK's intention to maintain the gross cap for initial integration of permanent carbon removals in the UK ETS (see Box 2).

Cost-effectiveness

Maintaining the gross emissions cap **compromises the cost-effectiveness** compared to a direct integration without restrictions (Policy Option 1). Rather than allowing the gross cap to rise and allowance prices to fall, there will be no impact on the allowance price if the gross emissions cap is maintained. This occurs since permanent carbon removals are not allowed to displace emissions reductions, thereby requiring firms to possibly undertake more costly abatement measures. This affects the financial burdens on compliance entities in the EU ETS, as permanent carbon removals could offer a cheaper alternative to higher-cost abatement measures in some sectors.

Market Functioning

This policy option does not contribute to solving possible **liquidity issues**, since the total number of allowances stays the same (the gross emissions cap is not allowed to increase). It does, however, reduce uncertainty regarding supply of permanent carbon removals and its impact on EU ETS compared to Policy Option 1. Since the total amount of allowances does not change, the possible technological uncertainty of scale and prices do not affect the market to the same extent. In the longer term, when the emissions cap approaches zero, the supply scarcity caused by maintaining the gross emissions cap could lead to increased **price volatility** and potential market distortions, unless additional measures are adopted.

Sustainability

Although slightly smaller than in Policy Option 1, integration with a maintained emissions cap still presents **sustainability risks** related to the unsustainable use of biomass. The model indicates that the retained gross cap slightly reduces the cumulative number of BECCS allowances entering the system between 2030 and 2050, thereby mitigating these risks to a limited extent. However, this policy option does not directly address specific impacts related to biomass availability. The modelling results suggest that BioCCS deployment could still be significantly higher than the levels projected in the European Commission's modelling for the 2040 climate target which are capped by constraints on the availability of sustainable biomass.

Implementability

On **implementability**, the **ease of implementation and administrative costs** are expected to be similar to Policy Option 1. Maintaining the gross emissions cap is a fairly simple design that would be relatively easy to implement. However, this policy option could have significant fiscal impacts for Member States. By replacing traditional EUAs with allowances for permanent carbon removals operators, Member States forego revenues gained from the auctioning of EUAs. At the same time, maintaining the gross emissions cap leads to higher allowance prices compared to Policy Option 1, which could uphold some of the auctioning revenues.[62] For some Member States, the impact will be mitigated by a reduction in other public funding for permanent carbon removals. Similar to Policy Option 1, this policy option could lead to excessive profits if operators of lower-cost carbon

62 The UK ETS Authority models that the revenue implications of the fall in price due to an increase in allowance supply under a direct integration (Policy Option 1) outweigh the impact of the fall in auction quantities under an adjusted cap (Policy Option 2).

removal technologies (such as CCS on biogas upgrading) receive the allowance price for their products. Sustained high allowance prices, due to the maintained cap, would exacerbate this trend compared to Policy Option 1.

Policy Coherence

In terms of **policy coherence**, similar to Policy Option 1, maintaining the gross cap is not fully aligned with the EU's economy-wide climate neutrality target, as it can only contribute to achieving climate neutrality for sectors currently covered by the EU ETS. Compared to Policy Option 1, this policy option could reach net zero for sectors under the EU ETS faster, because permanent carbon removals will provide additional net emissions reductions as indicated in Figure 6. In the longer term, as the gross cap continues to decrease, this policy option would likely not sustain enough demand for carbon removals to balance residual emissions within the EU ETS. Unless a net-negative emissions cap is designed with additional obligations, EU ETS integration with a maintained gross cap will not be sufficient to achieve net-negative emissions after 2050, because the ETS market would not create demand for carbon removals past net zero, since after that point the system generates no demand for carbon removals.

Box 2: Integrating Carbon Removals into the UK Emissions Trading Scheme (UK ETS)

There are no examples yet of an ETS integration with an adjusted cap, but the United Kingdom (UK) is exploring the policy option. In July 2023, the UK ETS Authority[63] announced plans to directly integrate engineered carbon removals[64] in the UK ETS as a long-term market for greenhouse gas removals (GGRs).[65] The Authority has stated that the earliest that integration could take place is 2028.

The overall idea is to allow GGR operators meeting certain market participation criteria to receive allowances for removing and storing carbon from the atmosphere. These allowances can then be sold on the UK ETS market, where ETS participants can buy them to meet their compliance obligations.

For initial integration in the UK ETS, the Authority is proposing to maintain the gross cap by removing a conventional UK Allowance (UKA) for every allowance generated by GGRs. According to the Authority, this will reduce the risk of abatement deterrence and maintain the incentive to decarbonise by the UK ETS in line with the existing net zero cap trajectory.

Further, in the early years of integration, the Authority intends to place additional supply controls on GGRs, putting quantitative limits on how many GGRs can enter the market to help manage the integration into the UK ETS.

In the long term, however, the Authority believes maintaining the gross cap may not support sufficient demand for GGRs. As emissions decline and GGR deployment increases, the UK ETS could reach a point where it might not have enough emissions allowances that can be replaced by allowances from GGRs. To address this, the Authority is considering setting a new and lower net cap at some point, i.e reducing the existing cap based on an expected supply of GGRs. GGR allowances would be allowed to enter the market in addition to the traditional UKAs (allowing the gross cap to increase) with the purpose of sustaining demand for GGRs in the longer-term.

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[63] Composed of the UK Government, Scottish Government, Welsh Government and the Department of Agriculture, Environment and Rural Affairs for Northern Ireland.

[64] Understood as Direct Air Carbon Capture and Storage (DACCS), Bioenergy with Carbon Capture and Storage (BECCS), wood in construction, biochar, and enhanced weathering

[65] UK ETS authority (2024).

Findings

The colour-coded indicators below summarise the findings from the analysis of Policy Option 2.

Criteria	Indicators	Impact
Incentive for permanent carbon removals	Deployment of permanent carbon removals	Both positive and negative impacts
Incentive for emissions reduction	Risk of abatement deterrence	Positive impacts
Cost-effectiveness	Cost-effectiveness	Negative impacts
Sustainability	Land sector risks	Both positive and negative impacts
Market functioning	Volatility	Both positive and negative impacts
	Liquidity	Both positive and negative impacts
	Fiscal impact	Both positive and negative impacts
Implementability	Administrative costs	Both positive and negative impacts
	Speed/ease of implementation	Both positive and negative impacts
	Fiscal impact	Both positive and negative impacts
Policy coherence	Deliverability of net-zero and net-negative	Negative impacts

3.3 Direct Integration into the EU ETS with Supply Controls (Policy Option 3)

Description of Policy Option

To address some of the risks of integration, different policy options to restrict and control the integration have been put forward. This has been explored by a number of publications and studies.[66] When considering integration with restrictions, there are two primary approaches: supply or demand controls.

Demand controls restrict who can purchase permanent carbon removals under an emissions trading system, for instance by only allowing certain sectors to use carbon removals (e.g. 'hard to abate' sectors), by allowing the use of carbon removals only up to a maximum percentage of the entities' emissions (e.g. 5% rising over time), or by allowing the use of removals only for process emissions.[67] Defining who should be allowed to use carbon removals, and how much they should be allowed to use, would be a complex exercise (e.g., the definitions of 'residual emissions' and 'hard-to-abate sectors' is constantly evolving). On one hand, demand controls could help to ensure that sectors continue to prioritise direct emissions reductions rather than offsetting with permanent carbon removals, and on the other hand, it could dampen the demand for permanent carbon removals from the EU ETS. The different forms of demand controls and their interaction with the other policy options would need to be analysed and considered when deciding whether to integrate permanent carbon removals into the EU ETS.

The scope of this analysis is limited to analysing possible **supply controls**. Setting a supply control would require additional information compared to Policy Option 1 and 2. Here, the policy makers would have to consider what an appropriate level of supply is in the first instance

66 E.g., UK ETS Authority (2024), Ecologic Institute (2023), Oxera (2022), and ICAP (2021).

67 Other proposals suggested some form of conditionality, with access to permanent carbon removals only being granted once a proportion of decarbonisation is demonstrated or once a credible decarbonisation plan has been submitted by the emitting entities.

and how that could change over time, and the resulting impacts. For example, supply controls could be aligned with the EU's climate targets and gradually relaxed (allowing more carbon removals to enter the EU ETS) as the EU moves closer to net zero.

In the following, two overall options for supply controls are be analysed:

1. **A supply control on the total amount of permanent carbon removal allowances** entering the EU ETS (Policy Option 3a). Based on the European Commission's modelling of the 2040 climate target, a quantitative limit of 75 million permanent carbon removals allowances in 2040 and 115 million allowances in 2050 are assumed in the modelling to illustrate possible impacts.[68]
2. **A supply control on the type of permanent carbon removal allowances** entering the system (Policy Option 3b). Here, a cap will be set on the amount of allowances from BioCCS and DACCS that are allowed into the EU ETS, rising by a set amount of carbon removals each year. The assumed limitations on biomass-based permanent carbon removals (CCS on biogas upgrading and BECCS) in this policy option align with the volumes captured annually by each technology in the European Commission's modelling of the 2040 climate target,[69] which are capped by constraints on the availability of sustainable biomass.

Assessment of an Overall Supply Control on Permanent Carbon Removals (Policy Option 3a)

Incentive for Permanent Carbon Removals

Compared to Policy Option 1, the allowance price signal would be higher in this policy option due to the overall supply control that would limit the amount of additional allowances entering the system. However, the supply control would lead to a smaller **deployment of permanent carbon removals** compared to Policy Option 1. The exact deployment volume would depend on the level of the overall supply control and on the price differential between the allowance price and the cost of permanent carbon removals.

As illustrated in Figure 7, applying a supply control could still result in allowances from CCS on biogas upgrading entering the system from the early 2030s. The slightly more expensive BECCS enters the system a few years later, but, in contrast to Policy Option 1, the maximum technological potential for deployment of BECCS is not reached. Without additional financial incentives (such as public funding or contributions from the voluntary carbon market), a very limited deployment of DACCS is expected towards 2050 in this policy option. As with Policy Option 1, it is important to stress that the ability of the EU ETS to incentivise deployment of permanent carbon removals strongly depends on the allowance price, and that the EU ETS alone might be insufficient in providing the necessary incentive for deployment of permanent carbon removals if future allowance prices are not significantly higher than today's level.

Incentive for Emissions Reduction

As shown in Figure 7, this policy option allows gross emissions in the EU ETS to increase as carbon removal allowances enter the system, **resulting in abatement deterrence**. The level of abatement deterrence will be lower than in Policy Option 1, since the regulated entities' reliance on permanent carbon carbon removals instead of reduction efforts would be restricted due to the supply control. The less strict the supply control, the greater the risk of disincentivizing emissions reduction activities.

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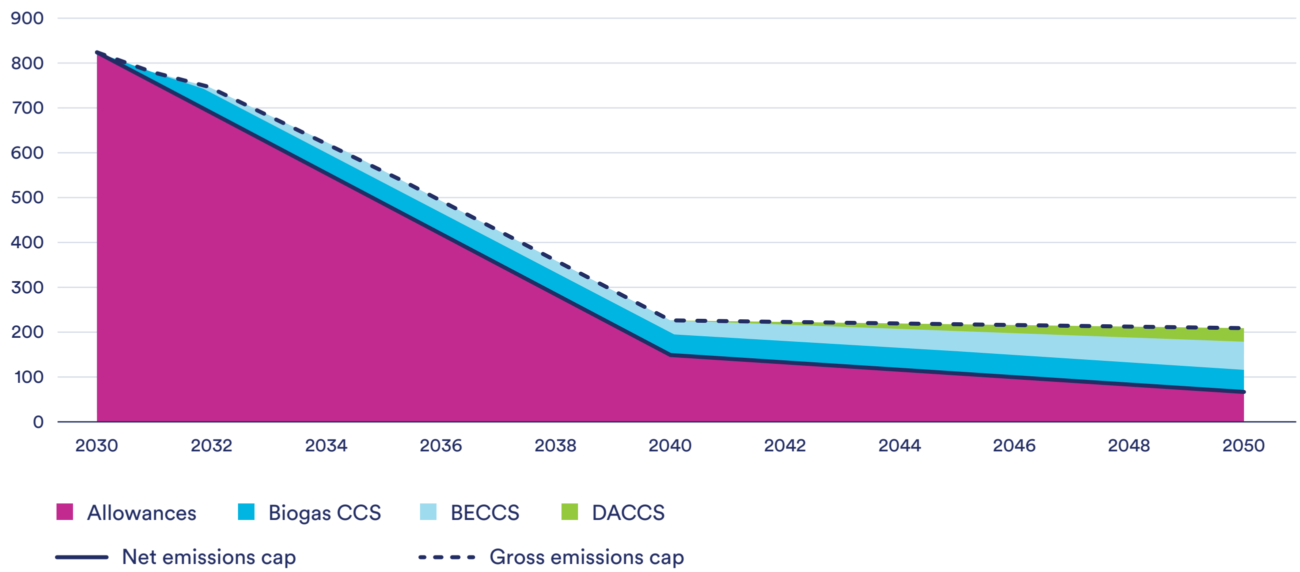
68 Estimates from the S3 scenario in the impact assessment accompanying the Communication from the European Commission. In the main scenario (S3) in the impact assessment, considerations of sustainable biomass availability limits BECCS expansion in the PRIMES model to 33 Mt CO_2 in 2040 in 2040 and 56 Mt CO_2 in 2050. In the modelling, biogenic emissions from biogas upgrading are assumed to be utilised instead of stored.

69 The report ignores that all CO_2 capture from biogas upgrading in the European Commission's modelling is utilised instead of stored.

Figure 7: Emissions Cap under Direct Integration with Overall Supply Restriction



Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050 while applying a yearly limit on total quantity at 75 million carbon removal allowances in 2040 and 115 million in 2050. As described in Appendix 1, the removal capacity is limited to 50 million tonnes per year for biogas CCS (carbon capture and storage on upgrading of biogas) and 100 million tonnes per year for BECCS (bioenergy with carbon capture and storage). There is no assumed quantity limit on DACCS.

Cost-effectiveness

This policy option is **less cost-effective** than Policy Option 1, since emitting entities would only be able to substitute more expensive emissions reductions with permanent carbon removals up until the supply control limit is reached. This leads to an increase in the overall costs of achieving a net emissions target within the EU ETS and increases the financial burden for companies in the EU ETS compared to Policy Option 1.

Sustainability

Sustainability concerns regarding the availability of sustainable biomass could be partially addressed depending on the level of supply control. The supply control would not target the specific impacts related to biomass availability directly since it places a limit on overall supply of carbon removals into the system, without targeting specific carbon removal technologies. Because BioCCS has lower costs than DACCS, BioCCS deployment will be incentivised first. The modelling results indicate that the BioCCS deployment could be higher than the projected levels in the European Commission's modelling for the 2040 climate target.

The less restrictive the limit on the total supply from permanent carbon removals, the higher the land sector risks, since the system will mostly stimulate BioCCS and no or very limited DACCS.

Market Functioning

Regarding **market functioning**, an overall supply control on permanent carbon removals would contribute to more **liquidity** by increasing traded volumes, but due to the supply control, the liquidity increase will be more limited than in Policy Option 1. Concerning **price volatility**, the technology uncertainty of permanent carbon removals and possible negative impact on volatility could be mitigated to some extent with the supply control, since it would decrease the amount of permanent carbon removals that can affect the gross emissions cap.
The level of the supply control could be changed over time. By setting the initial supply at a relatively low level, the European Commission could review how integration affects the functioning of the EU ETS. In the longer term, it could mitigate some of the issues around potential price uncertainty and market distortion due to supply scarcity if the supply control gradually increases towards net zero.

Implementability

On **implementability**, the ease of implementation and administrative costs are overall expected to be quite similar to Policy Option 1. The additional information requirements and effort to set and evaluate the supply control could require additional work from the regulators compared to Policy Option 1. The complexity for operators of permanent carbon removals could possibly increase compared to Policy Option 1 since they would need to factor in the supply control when they plan their investment decisions.

Concerning **fiscal impacts**, an overall supply control could manage some of the revenue impacts. This could potentially be attractive for Member States with relatively high revenues from the EU ETS, and/or Member States which are not incentivising or planning to support deployment of permanent carbon removals nationally in the short and mid-term. The prospects of permanent carbon removal operators earning **excessive profits** is also present in this policy option, and could in fact be higher than in Policy Option 1 since the overall supply control would lead to higher allowance prices than Policy Option 1.

Policy Coherence

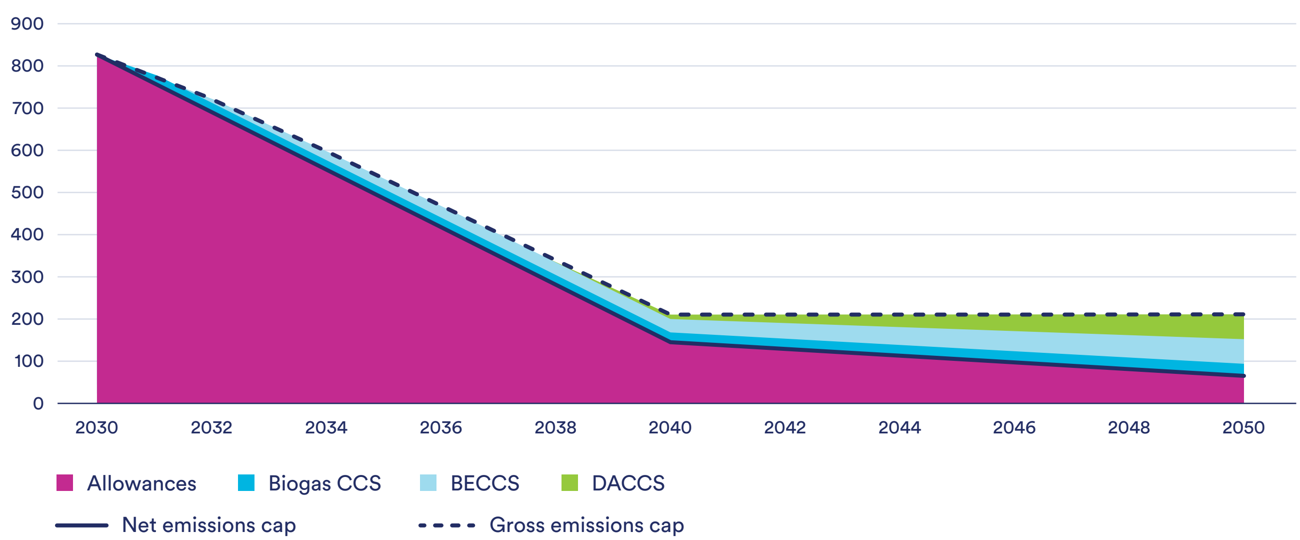
Depending on the exact limitation on supply, this policy option could at maximum bring sectors covered by the EU ETS to net zero and therefore not be sufficient in terms of the goal of economy-wide climate neutrality by 2050 the latest. This would depend on broader decisions regarding emissions trading in the EU as mentioned in Policy Option 1 and 2. Unless a net-negative emissions cap is designed with additional obligations, the policy option would in itself not be sufficient to deliver net-negative emissions after 2050 and additional policies and measures would need to be put in place to incentivize carbon removals beyond net zero (see Section 4.1).

Assessment of Supply Control on the Type of Permanent Carbon Removals (Policy Option 3b)

Incentive for Permanent Carbon Removals

As shown in Figure 8, the modelling results indicate that the biomass-based permanent carbon removals start entering the system in the beginning of 2030 like other policy options, but the volumes of CCS on biogas upgrading and especially BECCS entering the system are restricted by the the supply control, and the maximum technical potential of the two carbon removal methods is not reached at any point towards 2050.

Figure 8: Emissions Cap under Direct Integration with Supply Control on Allowances from Biomass-based Permanent Carbon Removals



Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050, with a yearly limit on biomass-based permanent carbon removals aligned with the European Commission's 2040 climate target modelling. As described in Appendix 1, the removal capacity is limited to 50 million tonnes per year for biogas CCS (carbon capture and storage on upgrading of biogas) and 100 million tonnes per year for BECCS (bioenergy with carbon capture and storage). There is no assumed quantity limit on DACCS.

Some deployment of DACCS is indicated from 2040 and onwards, but in practice, this strongly depends on the future allowance price. Overall, depending on the level of the restrictions, the supply control would **restrict the deployment of BioCCS**.

Incentive for Emissions Reduction

The supply controls place a limit on how much the gross cap can rise as carbon removals enter the EU ETS, effectively **lowering, but not eliminating, abatement deterrence** compared to Policy Option 1. Depending on the level of the supply control, the regulated entities' reliance on carbon removals instead of reductions would be restricted. The more carbon removal allowances are allowed into the system by the supply controls, the higher the risk of deterring emissions reductions.

Cost-effectiveness

Cost-effectiveness would be limited compared to direct integration without restrictions since emitting entities would only be able to substitute more abatement efforts with permanent carbon removals up until the supply control limit is reached. This leads to an increase in the overall costs of achieving a net emissions target for the EU ETS and increases the financial burdens for companies in the EU ETS.

Sustainability

Sustainability considerations regarding the availability of sustainable biomass could be directly targeted by restricting the volume of allowances from BioCCS entering the EU ETS, thereby to a greater extent controlling the deployment of BioCCS compared to Policy Options 1, 2 and 3a. As supply controls on biomass-based carbon removals are relaxed, there is an increase in sustainability risks associated with the land sector.

Market Functioning

As described above, the volume of carbon removal allowances entering the EU ETS is lower with supply controls than in Policy Option 1. As such, while a supply control on different permanent carbon removals methods could be used to ease carbon removal allowances into the EU ETS to manage potential market impacts from technology uncertainty in the shorter term, this policy option would contribute less to **market liquidity** compared to Policy Option 1. In the longer term, it could still help mitigate some of the issues around potential price uncertainty and market distortion due to supply scarcity, since the supply controls could gradually be increased towards net zero.

Implementability and Policy Coherence

Impacts on implementability, policy coherence and revenues would be the same as the overall supply control described above (Policy Option 3a).

Findings

The colour-coded indicators below summarise the findings from the analysis of Policy Option 3a and 3b.

Criteria	Indicators	3a. Overall Supply Control on Permanent Carbon Removals	3b. Supply Control on Type of Permanent Carbon Removals
Incentive for permanent carbon removals	Deployment of permanent carbon removals	Both positive and negative impacts	Both positive and negative impacts
Incentive for emissions reduction	Risk of abatement deterrence	Both positive and negative impacts	Both positive and negative impacts
Sustainability	Land sector risks	Both positive and negative impacts	Positive impacts
Market functioning	Volatility	Both positive and negative impacts	Both positive and negative impacts
	Liquidity	Both positive and negative impacts	Both positive and negative impacts
Implementability	Administrative costs	Both positive and negative impacts	Both positive and negative impacts
	Speed/ease of implementation	Both positive and negative impacts	Both positive and negative impacts
	Fiscal impact	Positive impacts	Positive impacts
Policy coherence	Deliverability of net-zero and net-negative	Both positive and negative impacts	Both positive and negative impacts

3.4 Integration into the EU ETS Through an Intermediary Institution (Policy Option 4)

Description of Policy Option

The final policy option explored in this report is that of conducting integration through an intermediary institution or public authority. The idea of creating an intermediary institution or authority, such as a 'European Carbon Central Bank'[70] or 'Carbon Clearing House',[71] to manage the integration of permanent carbon removals within the EU ETS has been explored through several different frameworks and mandates. These approaches vary in scope, complexity, and the extent to which they aim to intervene in the EU ETS and as such can be placed on a relative spectrum from a narrow to broad mandate. A literature review is performed in Appendix 3 to describe the various design options of such an intermediary institution. In all cases, this policy option would involve a comparably large degree of institutional involvement and governance delegation compared to directly integrating permanent carbon removals into the EU ETS (Policy Option 1, 2, and 3).

For the analysis of this policy option, a narrow mandate is applied, where the focus is on the role of a potential institution acting as the intermediary between operators of permanent carbon removals and the EU ETS. Its primary role would be to procure permanent carbon removals, place them into a pool, translate the carbon removal credits into allowances and manage their entry into the EU ETS. The quantity of carbon removals procured and entering into the EU ETS is determined by technology-specific procurement targets set by the policymakers as part of revisions to the EU ETS Directive.

Other possible functions of such an institution, such as managing the emissions cap and/or the price of allowances through a carbon removal reserve, are not analysed. Avenues for further research exist for an institution with a broader mandate to manage the integration of carbon removals beyond fulfilling the functionary role of an intermediary.

The primary functions of the intermediary institution conceptualised in this report would be:

1. **Procurement** of permanent carbon removals for placing in a pool.
2. **Market Integration:** Translate and adjust available carbon removal credits into allowances based on a rule-based framework set out in a revised EU ETS Directive.
3. **Market Information:** Provide transparent information to market participants about anticipated volumes of permanent carbon removals procured through a CCfD mechanism and available for integration.

Procurement of Permanent Carbon Removals

- The intermediary institution would operate under a mandate to procure carbon removal credits certified by the CRCF.
- A carbon contract for difference (CCfD) mechanism is assumed to be implemented as part of the procurement to bridge the possible gap between the cost of permanent carbon removals and the prevailing allowance price.[72] The intermediary institution would cover the difference between the two prices, determined by a competitive reverse auction. Separate auctions for the different types of permanent carbon removals are assumed by setting procurement targets for the various carbon removal technologies (i.e. CCS on biogas upgrading, BECCS and DACCS) by policymakers. As with Policy Options 3a and 3b, it would require additional information compared to Policy Option 1 and 2, since policymakers would have to consider what an appropriate level of supply is in the first instance and how that could change over time and the resulting impacts.
- In this conceptualisation, the intermediary institution would effectively act as the principal demand driver for permanent carbon removals in the EU, supporting the scaling up of new and emerging carbon removal technologies.

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70 Rickels et al. (2022).

71 Carbon Gap (2024).

72 Using existing architectures, such as the Innovation Fund, to act as the procurement lever for the intermediary institution could be beneficial. This model could operate similarly to the EU-wide auctions carried out by the European Hydrogen Bank, which awarded nearly €720 million to renewable hydrogen projects in its first auction. Similarly, the intermediary institution could offer an "Auctions-as-a-Service" mechanism, allowing Member States to co-fund additional permanent removal projects that have not been selected in the initial procurement rounds and have those removals added to the reserve, without having to set up separate national auction processes. Member States could set aside portions of their national budgets to participate in these auctions.

Market Integration and Information

- **Translation to allowances:** The intermediary institution could make permanent carbon removal credits available to the EU ETS by translating and adjusting CRCF credits into allowances. In this conceptualisation, the intermediary institution would be tasked with managing methodological adjustments so that CRCF units are fit for integration into the EU ETS as well as managing possible impermanence, for example with biochar.
- **Market Communication:** The intermediary institution would be tasked with informing market participants about the expected volumes of carbon removals to be added to the pool in the procurement rounds. The intermediary institution would centralise information gathering, overseeing the quantities and types of carbon removals supplied.

Assessment of Integration in the EU ETS Through an Intermediary Institution

Incentive for Permanent Carbon Removals

The proposed intermediary institution could create a large **incentive for permanent carbon removals** through a dedicated procurement mechanism, which would bridge the possible cost gap between permanent carbon removals and the allowance price. By having clear procurement targets for different technologies (i.e. BioCCS and DACCS), the institution would effectively support the deployment of these technologies over time. As such, integrating carbon removals through an intermediary institution is likely to provide strong financial incentives for the deployment of permanent carbon removals. However, this incentive would be contingent on the amount of funding that is available to the procurement scheme, as well as maintaining and likely increasing it over time given the volumes of permanent carbon removals required for the EU's climate targets.

Incentive for Emissions Reductions

In terms of **maintaining incentives for emissions reductions** within the EU ETS, an intermediary institution does not eliminate abatement deterrence, as market participants will substitute emissions reductions with carbon removals as allowances from permanent carbon removals enter the EU ETS. The degree of abatement deterrence depends on the volume of carbon removal allowances allowed into the market, but could potentially be lower than in Policy Option 1. Under the proposed model, the number of carbon removals procured and integrated into the EU ETS from the pool would be up to the policymakers through amendments to the EU ETS Directive, which increases the uncertainty and risk.

Cost-effectiveness

Compared to Policy Option 1, **cost-effectiveness** would be lower with this policy option, since the intermediary institution to some degree (based on procurement levels defined by the policymakers) would limit the influx of permanent carbon removals into the system, potentially requiring EU ETS participants to invest in more costly abatement options even if there is a demand for carbon removals. Additionally, while the proposed use of carbon contracts for difference (CCfDs) could manage the cost differentials between carbon removals and EU ETS allowance prices, it may raise concerns for the EU ETS forward market by reducing the need for market participants to hedge their risks. This, in turn, could hinder efficient price formation.[73]

Market Functioning

Integration through an intermediary institution in this conceptualisation is assumed to contribute to more liquidity by **increasing traded volumes of allowances**. However, in the case of the intermediary institution, effects on liquidity would heavily depend on the timing and volume of procured permanent carbon removals released through revisions to the ETS Directive.

Within the literature, one of the main functions highlighted for the intermediary institution is a role in reducing price volatility, as the EU could use the reserve of permanent carbon removals to stabilise prices during price spikes. However, with a narrow mandate without this market stabilisation role, effects on volatility would likely be contingent on the volumes set to be released into the system that are set by the co-legislators in revisions of the ETS Directive, which is, in turn, dependent on the size of the procurement pool built by the intermediary. The uncertainty associated with both of these aspects could influence prices and market expectations.

Sustainability

By setting predetermined technology-specific procurement targets for BioCCS and DACCS, the **sustainability risks** associated with the unsustainable use of biomass could be managed by the intermediary institution. However, this would depend strongly upon the level of procurement that the intermediary institution

[73] NEGEM (2021).

would carry out, especially for BioCCS. Since it would be up to policymakers to determine the procurement targets, it increases uncertainty if the institution will effectively handle sustainability issues. High levels of deployment of BioCCS could increase biomass use and pose risks to land use change, biodiversity, and food security if not managed properly. These concerns could be carefully balanced out when setting procurement targets for the different technologies.

Implementability

In terms of implementability, even with the relatively narrow mandate defined in this report compared to other set-ups such as an 'European Carbon Central Bank', setting up an intermediary institution still involves significant **administrative complexity**. A broad mandate allows for more flexibility but reduces the willingness of politicians to delegate powers to it, reducing its political feasibility. The political feasibility of this policy option is a key concern, given that the appetite for creating and empowering new institutions and authorities could be unlikely in the current political climate. Coordination between various EU bodies and Member States, as well as the need to establish new operational frameworks, presents considerable challenges. The **implementation speed** could be slower compared to direct integration models due to the need for institutional setup, legal frameworks, and political agreement. However, by leveraging existing structures like the Innovation Fund to act as the procurement lever for the intermediary institution, some of these barriers could be reduced.

In terms of **fiscal impacts**, Member States' auction revenues from traditional allowances would decrease as permanent carbon removal allowances enter the market, similar to the impacts seen in Policy Option 1. Additionally, the fiscal impact of funding the procurement could be significant, particularly for higher-cost permanent carbon removals such as DACCS, where there could be a large price differential between the allowance price and the price of procurement. These fiscal impacts are likely to grow as procurement efforts could be increased in light of climate targets.

Policy Coherence

In terms of **policy coherence**, setting up an intermediary institution could in principle be well-aligned with the EU's long-term climate targets, if the political will to mandate the institution with the task exists among policymakers. A phased expansion of the institution's mandate over time could also allow for dynamic adjustments, ensuring alignment with evolving climate policies, in particular achieving net-negative emissions. At the stage of net negative, the intermediary institution could in principle cancel carbon removals that are held in the pool and have not been retired, and use them to contribute to a potential net-negative emissions cap within EU ETS (see elaborated in Section 4.1).[74]

Findings

The colour-coded indicators below summarise the findings from the analysis of Policy Option 4.

Criteria	Indicators	Impact
Incentive for permanent carbon removals	Deployment of permanent carbon removals	Positive impacts
Incentive for emissions reduction	Risk of abatement deterrence	Both positive and negative impacts
Cost-effectiveness	Cost-effectiveness	Both positive and negative impacts
Market functioning	Volatility	Both positive and negative impacts
	Liquidity	Both positive and negative impacts
Sustainability	Land sector risks	Both positive and negative impacts
Implementability	Administrative costs	Negative impacts
	Speed/ease of implementation	Negative impacts
	Fiscal impacts	Negative impacts
Policy coherence	Deliverability of net-zero and net-negative	Positive impacts

74 Rickels et al. (2024).

3.5 Summary and Pathway to Integration

This analysis explores the integration of permanent carbon removals into the EU ETS through four approaches: 1) without restrictions, 2) with a maintained emissions cap, 3) with supply controls, and 4) through an intermediary institution. The analysis shows that integrating permanent carbon removals into the EU ETS would entail balancing trade-offs between environmental integrity, cost-effectiveness, and administrative/fiscal concerns.

A direct integration without restrictions would help create **demand for permanent carbon removals** and potentially lead to a substantial deployment of BioCCS from 2030 onwards depending on future allowance prices. DACCS deployment would most likely only occur with additional financial incentives such as public funding and/or contributions from the voluntary carbon market or if technology costs decrease in the future. Especially in the short run, the EU ETS alone may not provide sufficient incentives for the early deployment of permanent carbon removals due to the prevailing allowance price.

Direct integration without restrictions entails the **risk of reducing incentives for emissions reduction efforts**. By allowing the gross emissions cap to increase as carbon removals enter the system, regulated entities emit more by substituting reductions with permanent carbon removals. This creates abatement deterrence, potentially hampering the environmental integrity of the system. Another important risk is the **excessive use of biomass resources that could affect carbon sinks in the LULUCF sector and/or biodiversity**. In light of the lack of a carbon pricing regime in the land sector, increased biomass use for BioCCS could lead to land use change and, depending on the biomass resources used, potentially negatively impact the already challenged carbon sinks in the LULUCF sector. The analysis shows that, without targeted restrictions, the deployment of BioCCS could far exceed the levels assumed in the European Commission's impact assessment for the 2040 climate target, which is capped by constraints on the availability of sustainable biomass. Integrating **biochar** in the EU ETS could amplify some of the risks regarding abatement deterrence and sustainability due to its use of biomass resources and relatively low technology costs. Further analysis of **the impacts of biochar** on the environmental integrity of the EU ETS, deployment of other permanent carbon removal methods, and demand for biomass resources is needed. Any integration of biochar would need additional strict measures on permanence and liability.

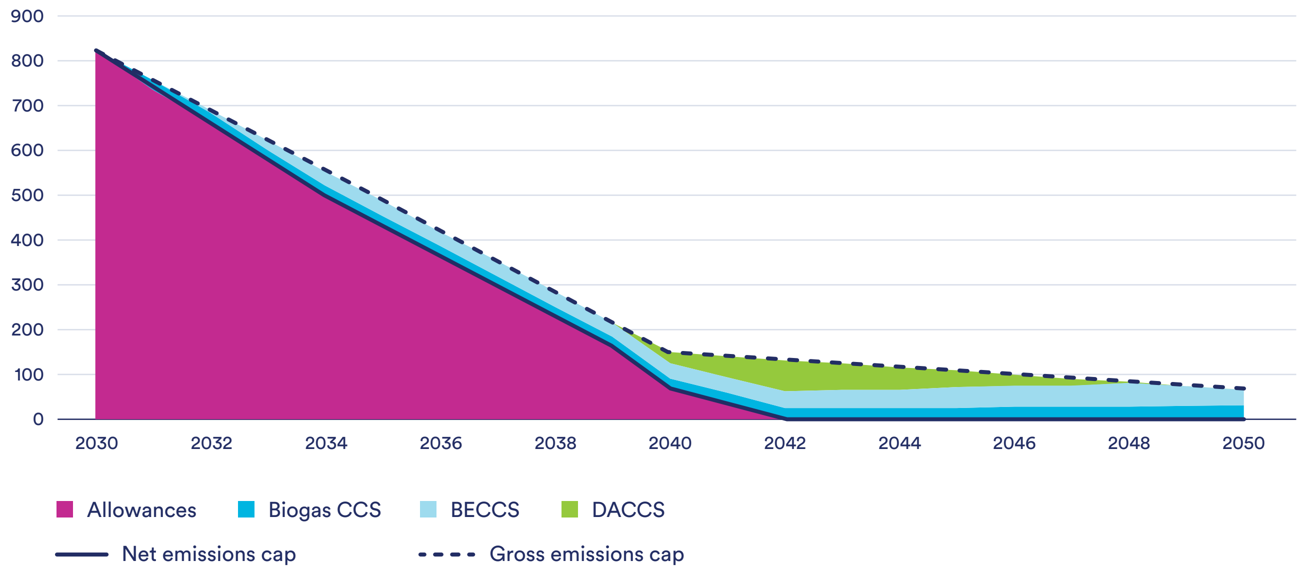
In every policy option, integrating carbon removals into the EU ETS increases the **administrative costs** for permanent carbon removal operators (setting up MRV and selling at auctions or into secondary markets) and the regulator (setting up new design elements such as MRV, delivery systems etc). The integration will also have **fiscal impacts** by lowering auctioning revenues for governments. These fiscal impacts are affected by the possible restrictions and could be mitigated by the accompanying reduction in the levels of public funding required for permanent carbon removals in some Member States. Another fiscal consideration is the possibility of **excessive profits** if carbon removal companies sell lower-cost permanent carbon removals in the EU ETS at an allowance price significantly exceeding their production costs. This may inadvertently divert ETS revenues away from Member States and other intended purposes, such as funding climate action in the EU.

This report has identified that an intermediary institution is not functionally necessary to carry out the integration of permanent carbon removals into the EU ETS. Giving over elements of control of the EU ETS to an independent institution is likely to prove politically challenging in the near- to mid-term. However, due to the current high costs of permanent carbon removals, the role of a procurement model/programme could be particularly beneficial as part of a suite of supporting policies needed to scale up the industry.

Based on the analysis, CONCITO and Clean Air Task Force recommends an introduction of a **combination of safeguards** (modelled in Figure 9 below) to ensure the environmental integrity of the EU ETS and address administrative/fiscal concerns, if permanent carbon removals are to be integrated into the system as part of the 2026 review:

- **Maintaining the gross emissions cap** for initial integration could effectively address the deterrence of emissions reductions and ensure the system continues to drive abatement.
- **Implement supply controls on different permanent carbon removal methods** to address sustainability risks concerning biomass-based permanent carbon removals as well as to manage potential fiscal impacts.
- Introduce **differentiated allowances** to enable a regulatory distinction between traditional emissions allowances and allowances from different permanent carbon removals methods and to enhance information to market participants and policymakers.

Figure 9: Direct Integration with a Maintained Emissions Cap and Technology Specific Supply Controls



Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050 while maintaining the emissions cap as well as applying a yearly limit on biomass-based carbon removals aligned with the European Commission's 2040 climate target modelling. As described in Appendix 1, Biogas CCS is capped at 50 million tonnes per year, and BECCS at 100 million tonnes per year.

The recommended safeguards and design features will have differentiated and **in some instances negative impacts on the demand pull for certain permanent carbon removals** (such as limiting the deployment of biomass-based permanent carbon removals), on the **cost-effectiveness** of the system as well as on **market liquidity**, the latter impacting the functioning of the market. Furthermore, as indicated in Figure 9, the supply of permanent carbon removals could exceed the demand as we move towards 2040. Due to the maintained gross emissions cap, in the longer run, there will not be enough traditional emissions allowances in the system that can be replaced by carbon removal allowances. At some point, the gross emissions cap could fall below the level of permanent carbon removals available for auctioning. Furthermore, the allowance price could potentially be quite high and volatile if the safeguards are kept untouched towards climate neutrality and no further adjustments are made (e.g. to the market stability reserve).

If allowance prices exceed politically acceptable limits, potential rapid policy interventions could compromise the environmental integrity of the EU ETS.

Integrating permanent carbon removals into the existing EU ETS1 could contribute to bringing sectors covered by the system to net-zero, but will be insufficient to achieve economy-wide climate neutrality in the EU. It would also be insufficient for delivering on the commitment of net-negative emissions after 2050 since the system will no longer provide incentives for carbon removals beyond net-zero. This is unless a net-negative emissions cap is designed with additional obligations and/or additional policies and measures are introduced. As illustrated in Figure 10, three overall stages of policy development could be needed to get to a net-zero and net-negative EU, if permanent carbon removals are integrated into the EU ETS.

Figure 10: Three Stages of Policy Development, if Permanent Carbon Removals are Integrated into the EU ETS

STAGE 1 Initial Integration (2026 review)	STAGE 2 Gradual Integration (towards 2040)	STAGE 3 Additional Long-term Policies (post-2040)
Safeguards and design features: Maintaining emissions cap, supply controls, permanence rules, etc. **Supporting policies:** Additional EU funding, stronger biomass regulation, etc. **Related processes:** Separate reduction and removal targets, EU ETS review, CRCF review, regulation of voluntary carbon markets, etc.	**Possible adjustments** in safeguards and design features towards climate neutrality based on review clause **Condition for adjustments:** Addressing risks (e.g. related to abatement deterrence and unsustainable biomass use) **Related processes:** Further evolution of emissions trading and/or additional policies etc.	**Introduction of additional policies and measures to get to a net-negative EU** such as Member States obligations, a net-negative emissions cap in the EU ETS, separate compliance mechanism, carbon takeback obligation etc.

Note: The figure is inspired by the work of Sultani et al. (2024) and Burke & Schenuit (2024) and is for illustrative purposes only. The stages are not necessarily mutually exclusive, and policy interventions (e.g. establishing a separate compliance market and/or Member States obligations) could occur in parallel.

In Stage 2, an enduring strong incentive for permanent carbon removals and functioning of the EU ETS could necessitate adjustments of the safeguards and/or additional policies. For instance, reducing the cap and then allowing allowances from permanent carbon removals to enter the market in addition to traditional EUAs, or setting a new higher gross emissions cap with continued deduction of traditional EUAs could be analysed. Any such changes would need an assessment of the effects on environmental integrity (e.g. adjustments would be conditional on addressing risks such as abatement deterrence and unsustainable use of biomass) and the effectiveness of the EU ETS, as well as the interplay with other possible changes in the system (e.g. the design features of the market stability reserve), the evolution of emissions trading, and introduction of additional policies more broadly.

A **review clause** at least 2 years after the entering into force of the provisions related to permanent carbon removals[75] will be needed as part of a **careful and gradual integration of permanent carbon removals into the EU ETS**. It should mandate the European Commission to assess the effects on environmental integrity and functioning of the EU ETS, before adjusting safeguards and design features. The review should also take into account the abatement costs under the EU ETS and other the development of supporting policies (e.g. the regulation of biomass use) and the evolution of emissions trading (e.g. an agricultural emissions trading system and/or a possible separate compliance market) when assessing the need for adjustments. In the following chapter, the report looks into possible short- and long-term policies and the possible evolution of emissions trading in the EU as mentioned in Stage 2 and 3.

[75] The timing of the review clause should take into account that the integration of permanent carbon removals should have taken effect to accurately assess the effects on environmental integrity and functioning of the EU ETS on one hand. On the other hand, possible adjustments in the safeguards should happen well before 2040 to give clarity for investments. The analysis in this report has assumed 2030 as the earliest possible date for integration in light of possible political negotiations after a legislative proposal in 2026 followed by a possible implementation period.

SECTION 4

Perspective

4.1 Supporting Policies

A suite of supporting policies could be considered ahead of and alongside integration into the EU ETS to ensure a sustainable deployment of permanent carbon removals to fulfil their critical role in achieving net zero and net negative thereafter.

4.1.1 Short-term Policies (Towards 2040)

Target Setting

Establishing **distinct and separate targets or sub-targets** for emissions reductions, nature-based carbon removals, and permanent carbon removals could be part of the climate architecture which can help to scale permanent carbon removals in the EU. This could be a part of the revisions of the EU Climate Law. Separate targets could establish the basis for a policy and obligation regime that improves the likelihood that targets are achieved. Such differentiation would recognise the differences between emissions reductions, permanent carbon removals and the LULUCF sector. By setting separate targets, the EU could ensure a balanced focus on both immediate emissions reductions and the scaling of both nature-based and permanent carbon removals, both of which are necessary for achieving climate neutrality by 2050 and moving towards net-negative emissions thereafter. Further consideration must be given to finding a balance between ensuring environmental integrity and cost-effectiveness when deciding on possible separate targets or sub-targets.

Additional EU Funding Tools

Scaling permanent carbon removals to the levels necessary to meet the EU's climate goals will require substantial public **funding and strategic support** for a portfolio of technologies along the innovation curve. Deployment at scale will incur significant costs, due to the capital-intensive nature of project investments, while securing long-term demand and certainty for investors, as investing in the nascent sector is still inherently risky. Furthermore, given the cost gap between the current carbon allowance price in the EU ETS and most applications of permanent carbon removals, particularly DACCS, additional funding mechanisms as part of the policy mix could be essential, if deployment is to be realised. As shown in a sensitivity analysis conducted in Appendix 2, only a quite low DACCS price in 2040 would lead to the deployment of DACCS to the levels indicated in the European Commission's impact assessment for the 2040 climate target. To overcome cost and investment barriers, both EU and Member State policymakers must develop a suite of policy tools tailored to each stage of technology development, commercialisation, and deployment, designed to drive innovation and create demand-pull in the short to medium term.

In this light, **additional EU funding tools**, such as public or public-private purchasing programmes, reverse auctioning, or carbon contracts for difference schemes, outside or in conjunction with the EU ETS (e.g. the Innovation Fund) should be examined to close possible gaps between the allowance price and permanent carbon removals, particularly for DACCS. At the same time, weakening the support for other technologies critical to providing deep and timely emission reductions (e.g. under the Innovation Fund) must be avoided.

Currently, in the US, which is leading in the deployment of permanent carbon removals, DACCS projects tend to rely on 'stacking' a combination of different incentives to overcome the cost gap between market carbon prices and the actual cost of carbon removal. This includes combining investment capital funding, tax credits, production tax credits, government grants, and voluntary carbon market credits. While many of these approaches will not be applicable in the EU context, the EU can draw from these experiences and consider adopting an approach tailored to each stage of permanent carbon removal technology development. Such an approach would ensure that projects receive adequate financial support across all stages, from research and development (R&D) to full-scale deployment as illustrated in Box 3.

Relationship to the Voluntary Carbon Market

The potential for using the voluntary carbon market (VCM) to finance permanent carbon removals covered by a compliance mechanism such as the EU ETS would need to be thoroughly assessed. Potential issues include ensuring additionality, if European actors sell carbon removal allowances and at the same time receive funding from the VCM, as well as potential issues around double counting and double claiming, if this financing is used for making climate claims.

Box 3: Financial Support at Different Technology Readiness

Research and Development (R&D) (TRL 1-5): For technologies in the early stages (Technology Readiness Levels 1-5), such as novel DAC methods, substantial public funding is needed to support R&D activities. This can include grants, subsidies, and collaborative research programs funded through initiatives like Horizon Europe and the Innovation Fund. Early-stage funding should prioritise technologies that demonstrate high permanence, scalability and cost reductions, and low environmental impact.

Demonstration (Dem) (TRL 6-9): For technologies progressing to the demonstration stage (TRL 6-9), where pilot projects and first commercial-scale deployments occur, support should shift towards de-risking private investments. This could involve advanced market commitments (AMCs), public procurement programs, and targeted financial instruments such as loan guarantees. Demonstration support should focus on technologies that are nearing commercial viability but still require proof of concept at scale.

Early Commercial Deployment (ECD) (Commercial Scale Deployments 1 to N): At this stage, which involves commercial-scale deployments from 1 to N (often 5-10), more structured support mechanisms like CfDs, reverse auctions, and national demand policies (e.g., the UK's GGR CfDs, Denmark's NECCS fund, and Sweden's BECCS reverse auctions) should be deployed. These instruments can provide long-term revenue certainty, encouraging private-sector investment and accelerating the scaling of permanent CDR deployment.

Expansion (Exp): For bankable technologies that have reached commercial viability, the focus should shift to creating a conducive regulatory and market environment to enable further expansion.

Transport and Storage Infrastructure

The **development of CO_2 transport and storage infrastructure** will be a critical component of the EU's policy mix for scaling up BioCCS and DACCS. Both of these engineered carbon removal methods depend on CO_2 infrastructure being available for the transport and storage of captured CO_2. Given that DACCS can be sited close to geological storage locations, provided there is sufficient renewable energy to power the plants efficiently, this allows for flexibility to minimise transport and storage costs. The proposed Net-Zero Industry Act (NZIA)[76] sets a target of developing 50 million tonnes (Mt) of CO_2 injection capacity by 2030, marking a major step in the right direction. However, additional policies at the Member State level are needed to develop adequate CO_2 storage across Europe, which will help build permanent carbon removal capacity. Integrating permanent carbon removals into the EU ETS and implementing demand driver policies could help secure demand for the CO_2 from these projects, help build economies of scale, and aid in the economics of developing storage sites available for both permanent carbon removals and conventional CCS by creating economies of scale in CCS cluster development. A robust backbone of CO_2 infrastructure will likely prove to be a key enabler for deployment, necessitating appropriate planning and funding mechanisms for cross-border infrastructure. The enabling policies, such as the regulatory framework for CO_2 transport, as well as breaking down barriers to international transport of storage, are other important parts of the policy mix to enable permanent carbon removals deployment in the EU.

Mitigating Risks of Unsustainable Biomass Use

The deployment of BioCCS should be prioritised in sectors with limited alternative mitigation options, as well as on existing biogenic point sources that can deliver negative emissions from current processes. However, it is important to keep in mind that existing uses may not be the most efficient or sustainable ones. For instance, if BioCCS is deployed in sectors with viable alternatives to biomass use (such as heat and power production), CCS investments would risk locking in undesirable biomass use.

Incentivising biomass-based carbon removals like BioCCS and biochar requires careful consideration of associated climate and environmental risks. While these technologies will be necessary for achieving EU climate targets, their deployment comes with risks related to an increase in biomass use. Competing demands for biomass use in the EU are increasing, and the absence of effective pricing of negative environmental externalities in the LULUCF sector risks leading to inefficiently high use of biomass, which in turn has negative impacts on land carbon sinks, biodiversity, and food security.
As such, as part of the policy mix, better prioritisation and stronger regulation of biomass use are needed in parallel with incentivising the deployment of biomass-based carbon removals. It could be considered to put in place pricing mechanisms to reflect losses in the land sector when biomass resources are utilised (e.g. covering the net emissions of burning biomass by emissions trading)[77] and other regulations on biomass use (e.g. limiting the role of biomass and biofuels in EU energy regulation and/or introducing further sustainability requirements for biomass use and BioCCS facilities). Without pricing mechanisms in place to reflect losses in the land sector when biomass feedstocks are utilised, supply controls on BioCCS allowances entering the EU ETS are needed to prevent excessive biomass consumption (as outlined in the analysis of Policy Option 3b). If the EU succeeds in adopting stronger biomass regulation (e.g. through better pricing/incentives in the land sector), the supply controls could potentially be loosened in the future.

4.1.2 Long-term Policies (post-2040)

As the EU progresses towards its targets of climate neutrality and net-negative emissions, the demand and supply for permanent carbon removals across all sectors will need to grow beyond covering just the EU ETS1.
An assessment could determine whether other sectors covered by emissions trading should also be allowed to use permanent carbon removals for their compliance obligations (see elaborated below). One long-term challenge for the EU is to establish a self-sustaining market for permanent carbon removals that ensures sufficient volumes are available in time for net zero and net-negative emissions while minimising public spending and fostering long-term private investment. Beyond climate neutrality, the EU will most likely need additional policies and measures to achieve and maintain a net-negative EU.

There are numerous regulatory models that could potentially be utilised by policymakers to get to a net-negative EU (such as Member States obligations, net-negative emissions cap, carbon takeback obligation,

[76] Regulation (EU) 2024/1735.

[77] CONCITO (2024a).

separate compliance mechanisms etc.). While the emissions cap in the EU ETS may stay positive or merely reach zero under a net-zero EU, the necessity to reach net-negative emissions begs the question of who will pay for the necessary permanent carbon removals and how. This entails not only a discussion on if (and how) to integrate permanent carbon removals into the EU ETS, but also on much broader and important topics of effort sharing across Member States, across sectors (e.g. regulated entities), and over time.[78]

One option could be moving towards a **net-negative emissions cap** allowing the emissions cap to go below net-zero. It is more challenging to determine which entities will have the obligation to become net negative under the EU ETS. Many separate options exist such as 1) putting additional obligations on regulated entities (e.g. through additional/changing the obligation to surrender allowances, and/or additional exchange rate measures),[79] 2) changing the regulated entities within the EU ETS over time, 3) additional allowance purchases by an intermediary institution in addition to the emissions cap. This could possibly be connected directly or indirectly with a separate compliance mechanism, as mentioned earlier in the report.

A **carbon take-back obligation (CTBO)** is another possible option put forward to secure long-term demand. The conventional formulation of this policy requires fossil fuel producers to balance a growing percentage of the carbon they produce with geological storage of CO_2. This approach could result in higher-cost sources of CO_2, such as DACCS, only being incentivised after lower-cost fossil CO_2 sources have been exhausted. However, a variation on the CTBO concept could require a portion of the take-back obligation to be satisfied through permanent carbon removals, thereby helping to ensure demand for these technologies is present throughout the duration of the scheme. In California's proposed Carbon Dioxide Removal Market Development Act (SB308), large emitters would be required to purchase carbon removal credits according to their emissions, with the percentage of emissions covered increasing from 1% in 2030 to 100% by 2045. Other policy options, such as **Member State obligations** (e.g. net-negative targets), or a **separate compliance mechanism** could also be relevant to tackle long-term demand issues but require further research on possible effects and their operationalisation in the EU.

The trade-offs between environmental integrity, cost-effectiveness, and administrative/fiscal concerns identified in this report are also relevant for many other policy interventions in this area.

4.2 Evolution of Emissions Trading in the EU

Emissions trading in the EU is not fixed but is constantly evolving in light of climate ambitions and other political dynamics. Discussions around the possible integration of permanent carbon removals in the EU ETS will be affected by and linked to other possible policy changes to the system. As recommended by the European Scientific Advisory Board,[80] the emissions trading systems must be made 'fit for zero', and the discourse on the 'endgame' of the EU ETS[81] (when the supply of allowances approaches zero) is evolving with respect to issues around the functioning of the market (e.g. higher price volatility and lower liquidity) and policy uncertainty.[82]

The European Commission has already expressed that the **2026 review of the EU ETS** will assess several other issues,[83] which can directly or indirectly affect a possible integration of permanent carbon removals and the discussion around the 'endgame' of the systems. This includes, but is not limited to, the examination of 1) the linear reduction factor, 2) management of CCU, 3) the Market Stability Reserve (e.g. the MSR's key design features and treatment of allowances from permanent carbon removals), 4) inclusion of municipal waste incineration (potentially broadening the scope of possible BioCCS applications), 5) carbon leakage measures (e.g. eligibility of carbon removal under the carbon border adjustment mechanism), and 6) linkage to other carbon markets (e.g. interactions and possible

78 La Hoz Theuer et al. (2021).

79 E.g. a smaller than one exchange rate between permanent carbon removals and allowances. Permanent carbon removal operators must therefore provide more than 1 tonne of removed CO_2 in order for an allowance to be issued.

80 European Scientific Advisory Board on Climate Change (2024).

81 Pahle et al. (2023).

82 Governments and regulatory authorities may face pressure to intervene and adjust the system to address possible challenges posed by near-zero allowances. This could lead to changes in regulations and policies, which in turn can create uncertainty for the actors involved.

83 European Commission (2024e).

conflicting rules on integration of permanent carbon removals). Some stakeholders[84] have begun to examine the inclusion of international carbon credits. In parallel, work on financing permanent carbon removals is ongoing, including alternative options to the integration of carbon removals into the EU ETS (e.g. possibly setting up a separate compliance mechanism for carbon removals connected directly or indirectly to the EU ETS).

Decisions on the **linear reduction factor post-2030** will need to be examined in light of its role in ensuring the upcoming 2040 climate target and a trajectory to climate neutrality and net-negative EU. At the same time, further changes that could generate instability for the investments taking place in the sectors subject to the EU ETS must be limited to the greatest extent possible. This report suggests that the emissions cap will be maintained for initial integration, if permanent carbon removals are included in the EU ETS, so for each extra carbon removal allowance entering the EU ETS, one fewer traditional EUA is released at auction.

The handling of carbon removals would also need to factor in possible changes regarding the **management of carbon capture and utilisation (CCU)** under the EU ETS since it could increase demand and utilise CO_2 as BioCCS and DACCS.[85] It is critical that this will not only be based on considerations of accounting and double counting of non-permanent CCU but that the final policy design focuses on ensuring the environmental integrity of the EU ETS and comparing the effectiveness of CCS, carbon removals and CCU in terms of climate benefits and costs in the CO_2 value chain. For example, high demand for a limited amount of biogenic CO_2 could occur if both storage and utilisation of biogenic CO_2 are strongly incentivized through EU regulation.[86] CATF and CONCITO will be looking further into this topic and will publish a brief on the management of CCU in the EU ETS next year.[87]

In parallel, there is an ongoing debate on the potential introduction of an emissions trading system in the agricultural food value chain (AgETS) and the possible linkage of carbon removals in the land sector (carbon farming).[88] It relates to more fundamental questions around where and how different types of carbon removals should be accounted for and incentivised in EU climate policy. Many carbon farming activities have significant issues with impermanence and risk of reversals (e.g. through changes in land use, wind, droughts, insect damage, and wildfires). Other issues include questions of additionality (e.g. uncertainties establishing trustworthy baselines), MRV (such as limited robustness and possible high costs), and high risks of abatement deterrence, if carbon removals are included directly in an AgETS. In this light, a first step could be to **disconnect an AgETS and carbon removals** and incentivise LULUCF removals through other means (e.g., using revenues from an AgETS to LULUCF fund removals).[89]

Furthermore, the evolution and possible policy changes to the **emissions trading for buildings, road transport and additional sectors (EU ETS2)** could also affect the policy decision. These sectors are expected to be responsible for a proportion of the residual emissions in 2050 and could therefore also be relevant in terms of permanent carbon removals. It should also be assessed whether actors from both emissions trading systems should be allowed to use permanent carbon removals for their compliance obligation. The safeguards placed on the integration in the EU ETS1 would to a great extent also apply to the EU ETS2.

This possible evolution of emissions trading in the EU stresses the need for strong coordination of the policy changes across the European Commission, Member States, European Parliament, companies, NGOs and think tanks to ensure the effectiveness and environmental integrity of emissions trading in the EU.

84 European University Institute and Delbeke, J., (2024).

85 EU ETS installations will not need to surrender allowances for GHG emissions that are 'permanently chemically bound in a product' (in practice only mineral carbonates used in some construction products) – also known as permanent CCU. The 2026 review will assess whether the CO_2 potentially released from non-permanent CCU products and fuels should be accounted for at the point of emission to the atmosphere ('downstream accounting') or when the CO_2 is initially captured ('upstream accounting').

86 The analysis needs to consider how to best use the biogenic CO_2, since we cannot realistically access all the biogenic CO_2 in the EU due to sustainability (e.g. cost and competition on biomass resource and possible negative impact on LULUCF) and other factors (e.g. capture rates, limited operating hours, installation size, transport barriers etc.).

87 See joint press release from CONCITO and CATF.

88 European Commission (2023).

89 CONCITO (2024b).

APPENDIX 1

Modelling Methodology

Overview

This appendix will provide a detailed explanation of the modelling approach employed in the preceding analysis of integrating permanent carbon removals into the EU ETS. As mentioned, the modelling approach is a simplified economic analysis designed to illustrate potential trends arising from the integration. Thus, the results presented should not be interpreted as a precise forecast or projection. Instead, the model offers stylized scenario-based estimates of how the integration of permanent carbon removals could affect the EU ETS based on economic factors. Despite the model's simplified nature, it arguably incorporates the most critical components of integrating permanent carbon removals into the EU ETS – marginal abatement costs and the marginal costs of various permanent carbon removal technologies.

At its core, the model seeks to find an equilibrium between the marginal abatement cost of reducing emissions and the marginal cost of permanent carbon removals. This equilibrium reflects the economically efficient point at which carbon removals would enter the EU ETS,[90] balancing the costs of emissions reductions with those of carbon removals. As such, the most crucial assumptions in the model are those regarding these costs. The model does not generate an allowance price since it is only concerned with the cost of abatement and carbon removals.

Marginal Abatement Costs

The marginal abatement costs in this analysis are derived from the European Commission's impact assessment (IA) of the 2040 climate target.[91] In the IA, carbon values are specified for three key scenarios (S1, S2, and S3), as well as for climate neutrality by 2050, with each carbon value linked to a corresponding emissions level. For the purposes of this model, these emissions levels have been adjusted to sectors covered under the EU ETS. This allows for an estimate of the likely marginal abatement cost at each emissions level – see Figure A1. Marginal abatement costs are adjusted to 2024 prices.

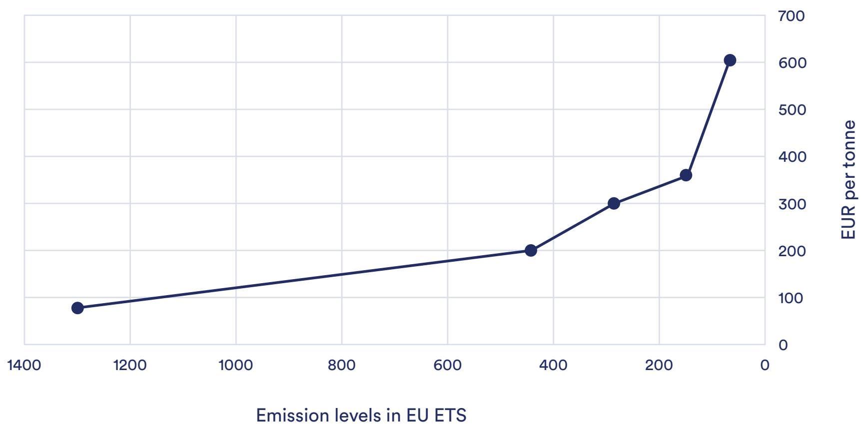
However, there are certain limitations to this approach. First, it does not account for changes in marginal abatement costs over time, as the model links marginal costs solely to emissions levels. Second, the IA assumes the implementation of additional policies, such as the adoption of alternative fuels, which would have an impact on the marginal abatement cost for each emissions level. Despite these limitations, other available estimates of marginal abatement costs also have significant shortcomings. Therefore, the report has chosen the abatement costs based on the IA for our primary scenario. However, for sensitivity analysis, the marginal abatement cost data for heavy industry in the LIMES model from Potsdam Institute for Climate Impact Research are used.[92]

90 Given that no market failures exist like arbitrage in the LULUCF sector and information asymmetries regarding the price evolution of key carbon removal technologies.

91 European Commission (2024f).

92 Osorio et al. (2021).

Figure A1: Marginal Abatement Costs in the Modelling



Permanent Carbon Removal Technologies

The marginal costs of removals used in this analysis is not found endogenously in the model but is instead an exogenous input. Hence, the model does not engage in complex investment decisions when it comes to the deployment of carbon removal technologies. Instead, our model simply receives specific cost input for the four selected carbon removal technologies – CCS on upgrading of biogas, BECCS, biochar, and DACCS. For each technology, the annual increase in removal capacity is limited to 25 million tonnes per year. This is done to reflect scale-up limitations.

Since all biogenic resources are inherently limited, the deployment of all biomass-based carbon removal technologies (CCS on biogas upgrading, BECCS, and biochar) comes with specified annual quantity limitations. This means there is a limit to the removal capacity for each of these technologies. On the other hand, DACCS has no such constraint in the model. The modelled scenarios indicate very little DACCS deployment, so constraints on its technical potential like the long-term development of power grids and other relevant infrastructure are not included.

Costs are constructed as a range to reflect the variation in the cost within each biomass-based carbon removal technology. Further, the aforementioned quantity limitation is distributed evenly across this cost range so different amounts of carbon removals are available from a BioCCS technology dependent on different cost levels. Table A1 gives an overview of the cost ranges as well as quantity limitations for each carbon removal technology.

Table A1: Cost Ranges and Quantity Limitations for Carbon Removal Technologies

	Price Range in EUR per Tonne	Limit in Million Tonnes per Year
Biochar	50-200	125
CCS on biogas upgrading	50-150	50
BECCS	150-250	100
DACCS	335	None

93 Deng et al. (2024) further indicate that, with spatial considerations, biochar prices vary between -12 and 173 EUR per tonne throughout China. However, we do not consider this price range as it pertains too specifically to local conditions.

94 Higher cost of pyrolysis oil will yield a more profitable biochar production since pyrolysis oil is a significant byproduct of biochar production.

Biomass-based Technologies

Based on a review of the existing literature, the **cost range for biochar** was chosen to be 50 to 200 EUR per tonne of CO_2 removed. In the academic literature, Saharudin et al. (2024) report costs in the range of 55 to 185 EUR per tonne, Buss et al. (2022) report 75 to 135 EUR per tonne, and Fawsy et al. (2021) report 65 to 160 EUR per tonne. Additionally, Deng et al. (2024) report that the average cost of biochar produced from various feedstocks ranges from 53 to 129 EUR per tonne, with a mean value of 80 EUR.[93] Further, the CIP Foundation (2024) reports that the current price of biochar is 130 EUR per tonne in the voluntary carbon market, while Ea Energianalyse (2024) estimates that with a high sales price of pyrolysis oil, the current technology could yield production costs as low as 60 EUR per tonne.[94] Biochar is not represented in the European Commission's modelling today, as it is assumed that all products resulting from the pyrolysis of biomass during the production of biofuels are under gaseous form and subsequently captured. A range of 50 to 200 EUR per tonne is assumed to account for all the discussed price ranges.

In the model, **biochar largely competes for the same biogenic resources as CCS on biogas upgrading and BECCS**. However, the modelling assumes that some biogenic resources are exclusive to BECCS due to considerations regarding CCS on Waste-to-Energy (WtE) facilities. According to the Danish Energy Agency (2024), WtE facilities both have economically favourable conditions that make biogenic CO_2 capture very profitable due to high full load hours and existing incentives for fossil CCS. At the same time, increasing sorting rates will yield greater economic costs, while some waste streams might be less desirable for biochar production since they pose greater toxicity risks to human health (Ndirangu et al. 2019). Therefore, biochar is unlikely to compete for all of BECCSs' biogenic resources. The amount of biogenic resources that are exclusive to BECCS is based on Rosa et al. 2021. They find that 27-45 million tonnes of biogenic CO_2 can be captured at WtE facilities in the EU while other collectible waste streams, such as agricultural waste and food waste, goes to biogas production. The report uses the lower bound of this estimate, 27 million tonnes of biogenic CO_2, as the biogenic resources that are exclusive to BECCS. This means that the quantity limitation on biochar is the biogenic potential it shares with CCS on biogas upgrading and BECCS, 125 million tonnes, minus the amount that has already been used by those technologies at any given price level. It is assumed that the amount of CO_2 used for storage is deducted from the total biogenic potential since the remaining biogenic resources reenter the economy as pyrolysis gas, pyrolysis oil, and heat. The interlinkages between biochar, CCS on biogas upgrading, and BECCS have been simplified for modelling purposes, but in reality, they are likely much more complex.

Further, the **permanence of biochar** is being discussed. According to Sanei et al. (2024), high-temperature pyrolysis yields biochar that is compositionally indistinguishable from pure inertinite maceral with a conservative half-life of 100 million years. From a policy perspective, this would make the inertinite part of biochar permanent making it more suitable for ETS integration. On the other hand, Woolf et al. (2021) and Azzi et al. (2024) assume that no fraction of the biochar is as stable as pure inertinite, and suggest that high quality biochar has a permanence of 82% to over 90% after 100 years, and between 74% to over 90% after 500 years, depending on the decay model used. There is still a debate on which methods should be applied. Further, other elements are being discussed such as a decreasing albedo effect that could lead to up to a 22% loss in its total climate effect according to Meyer et al. (2012). In the modelling, however, it is simply assumed 100% permanence of biochar and no adjustments are made based on changes to soil properties. This needs further analysis.

The **cost range for CCS on biogas upgrading** is assumed to be 50 to 150 EUR per tonne of CO_2 removed based on current CCS on biogas upgrading costs and findings from academic research. In 2024, the Danish Energy Agency awarded its first grants for large-scale CCS on biogas upgrading under its NECCS Scheme,[95] with the subsidy level reaching 130 EUR per tonne of CO_2 for the largest project.[96] This project is expected to begin operations in 2026. Existing literature suggests even lower costs: Gentile et al. (2022) estimate CCS on biogas upgrading prices could drop to 108 EUR per tonne by 2030, while Kubis et al. (2023) highlight that for high-purity CO_2 streams, such as biogas upgrading, costs could fall to 38 EUR per tonne. To account for this range of current prices and estimates from the literature, a 50 to 150 EUR per tonne cost range is assumed.

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95 The NECCS scheme is a tender supporting negative CO_2 emissions obtained through the capture and permanent geological storage.

96 The two other winning bids came in at 150 and 350 EUR/tonne for much smaller volumes.

97 Estimate corrected to exclude the UK.

Furthermore, the **CCS on biogas upgrading quantity limitation** is set at 50 million tonnes. According to a prior analysis by CONCITO (2023), if all biogas produced today were upgraded to biomethane and its CO_2 captured, the EU could store 21 million tonnes of CO_2 annually instead of releasing it into the atmosphere. However, Rosa et al. (2021) estimate that utilising current biomass waste streams could raise this capture potential to between 51 and 81 million tonnes.[97] Falling within this range, 73 million tonnes of CO_2 would be available for capture from biogas production in RePowerEU's 2030 target for biomethane. However, to account for the fact that not all biomass waste streams will be used for biogas production, a capture potential of 50 million tonnes is assumed in the modelling.

Based on a review of the relevant literature, the **cost range for BECCS** is assumed to be 150 to 250 EUR per tonne of CO_2 removed. In the literature, cost estimates vary widely and outcomes strongly depend on biomass prices, electricity prices, heat prices, technological development, and local conditions and infrastructure. Since the cost of BECCS is the most important in the post-2030 period, our cost range leans towards estimates that consider the same timeframe. Abegg et al. (2024) provide both a literature review as well as an expert assessment of possible price developments. The expert average min-max range for 2030 was 154-266 EUR per tonne while being 132-266 EUR per tonne in 2040. While other estimates vary, 150-250 EUR per tonne is not out of line with the literature presented by Abegg et al. (2024). The range is also consistent with modelling contracted by CONCITO (2024a) in the Danish context. The analysis shows that BECCS becomes profitable on existing biomass units from 160 EUR per tonne but that prices need to rise to over 200 EUR per tonne to incentivize larger amounts in 2040.

Further, the **quantity limitation on BECCS** is based on work done by Rosa et al. (2021) and CONCITO (2023) as well as the European Commission's impact assessment for the 2040 climate target. Rosa et al. (2021) estimated that currently between 110 and 140 million tonnes of biogenic CO_2 is released from large industrial point sources in the EU. Expanding on the methodology from Rosa et al. (2021), a CONCITO report found that around 190 million tonnes of biogenic CO_2 is likely being emitted from large energy and industry point sources. However, to reflect that it will not be feasible to capture all biogenic CO_2 due to economic and technical constraints, the quantity limitation must be considerably lower. As a reference point, BECCS generated almost 80 million tonnes of carbon removals in 2040 in the impact assessment for the 2040 climate target when the S3 scenario was run in POTEnCIA.[98] However, since estimates vary so widely and there is no consensus on the feasibly obtainable potential of BECCS, a quantity limit of 100 million tonnes is assumed in the modelling. In practice, modelling results do not differ drastically between a broad range of quantity limitations, even between 80 million tonnes and 190 million tonnes. BECCSs' crowding-out effects on DACCS remain largely the same, and the central difference is the absolute number of BECCS entering the system and thus the gross emissions cap.

DACCS

DACCS costs are based on Sievert et al. (2024) who provide cost ranges based on cumulative capacity worldwide. Grant et al. (2021) report that the median expert estimate of DACCS deployment is just above 1 Gt in 2040. At 1 Gt, Sievert et al. (2024) projects that DACCS costs are 320 EUR per tonne for liquid solvent DACCS, 351 EUR per tonne for solid sorbent DACCS, and 354 EUR per tonne for CaO ambient weathering DACCS. Since DACCS primarily enters the system after 2040, a **DACCS price of 335 EUR per tonne** is assumed as a middle ground between the liquid solvent, solid sorbent, and CaO ambient weathering DACCS technologies. The DACCS price is kept constant at 335 EUR per tonne by assuming a constant cumulative capacity of 1 Gt outside of the EU ETS to reflect uncertainties in both technology costs and deployment. This is also evident in Sievert et al. (2024) who report that, with 90% confidence, prices for DACCS range from 203 to 750 EUR per tonne at a 1 Gt deployment. As opposed to biomass-based permanent carbon removal technologies, a price range was not chosen for DACCS since the quantity available at a given price level is less obvious. Instead, to handle this uncertainty, sensitivity analysis for all policy options is provided in Appendix 2 where DACCS prices are at 250 EUR per tonne.

98 We chose not to look at the PRIMES numbers for BECCS since they are partly generated by a hard cap on biomass use put in place to protect LULUCF removals but has no base in the current policies.

Additional Model Assumptions and Specifications

Beyond marginal abatement costs and marginal carbon removal costs, assumptions regarding the **emissions cap** are a key determinant for model outcomes. As the emissions cap lowers, the marginal abatement costs increase, and the more permanent carbon removals enter the EU ETS. In the analysis, it is simply assumed that the emissions cap is equal to the remaining emissions in the EU ETS sectors according to the impact assessment for the 2040 climate target from the European Commission. Alternatively, the emissions cap could be modelled as specified in the latest revision of the EU ETS, where the last allowance[99] will be issued around 2040 (with aviation and banked allowances it gets to zero in 2045). However, the existing linear reduction factor was chosen to be used exclusively as a sensitivity scenario due to the system being up for revision in 2026, and the emissions cap therefore not being finally determined post-2030.

Another key assumption is that regulated entities engage in **no banking of allowances**. This means that all the additional allowances coming into the system in any given year will be used to generate emissions and thus retired. This is similar to stylized illustrations of a frozen policy scenario in the European Commission's impact assessment for the 2040 climate target.

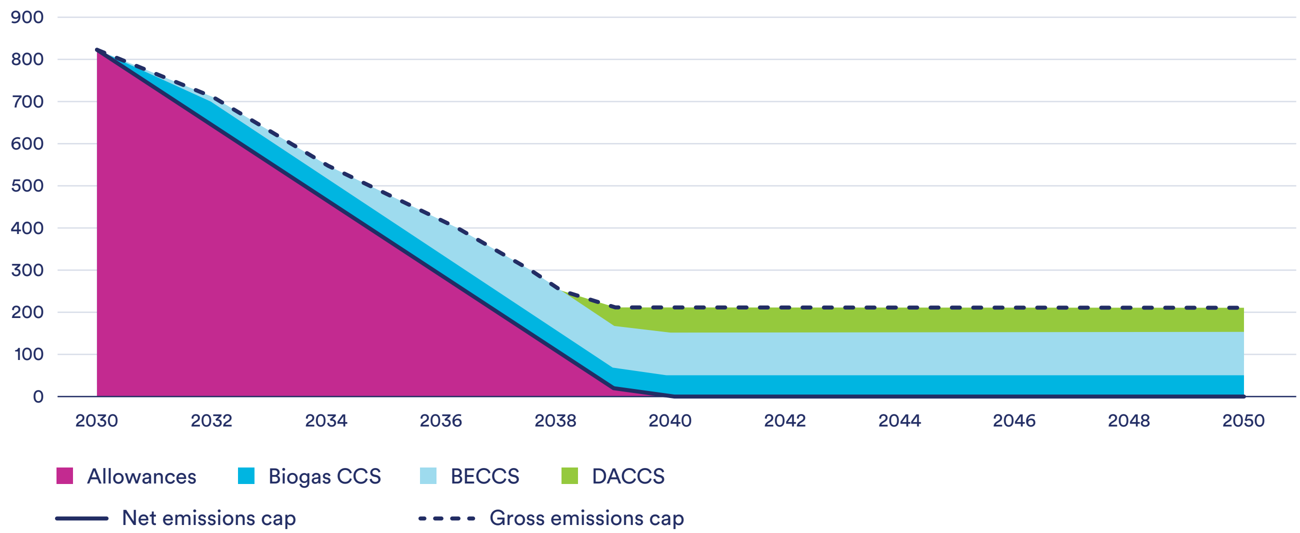
Although CCU could have a large impact on the deployment of permanent carbon removals, **no explicit assumptions are made regarding the use of CO_2 for CCU**. However, implicitly, CCU does affect other model inputs. These factors include the emissions level within the EU ETS, the quantity limitation on BECCS, and the cost of carbon removal technologies.

99 Except for allowances specifically designated for the aviation sector.

APPENDIX 2

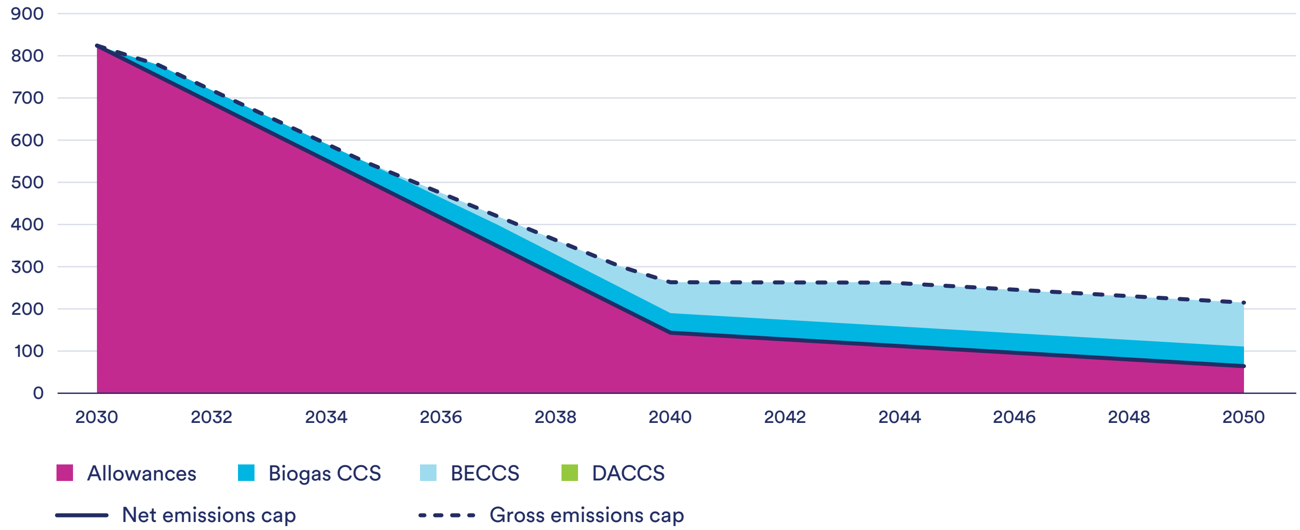
Sensitivity Analysis

Figure A2: Emissions Cap under Direct Integration without Restrictions and a Continuation of the Current Linear Reduction Factor



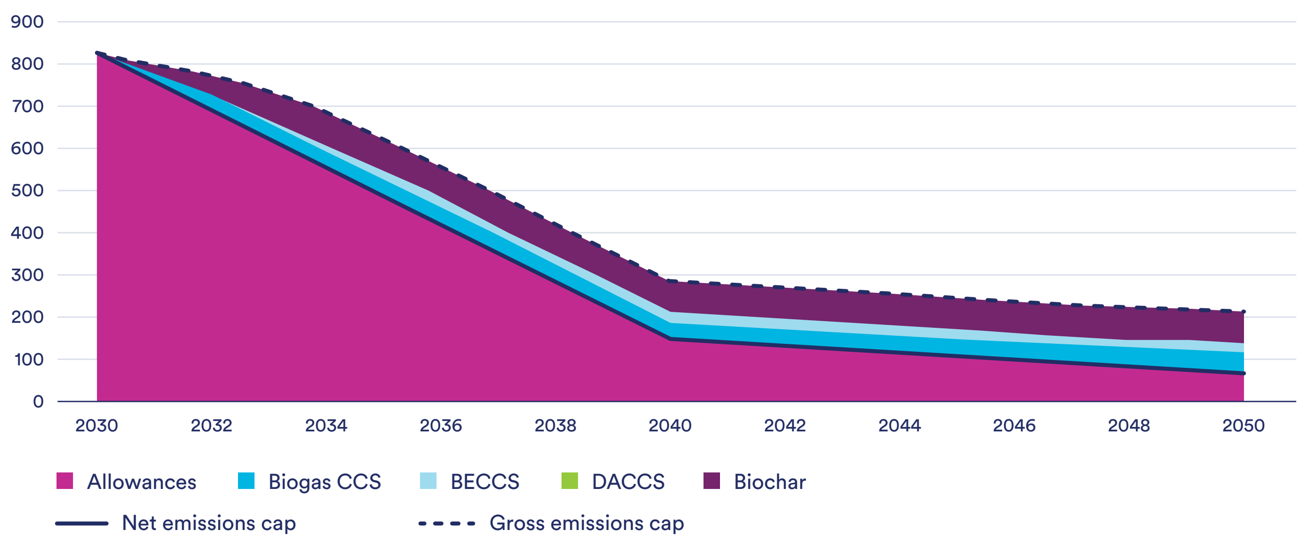
Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050 without restrictions, assuming a continuation of today's linear reduction factor. Allowances issued specifically to aviation are not included. This means the emissions cap reaches close to zero around 2039. Same maximum capacity limits are applied as in the base analysis, i.e. 50 million tonnes per year for biogas CCS, 100 million tonnes per year for BECCS, and no quantity limit for DACCS.

Figure A3: Emissions Cap under Direct Integration without Restrictions and Lower Marginal Abatement Cost



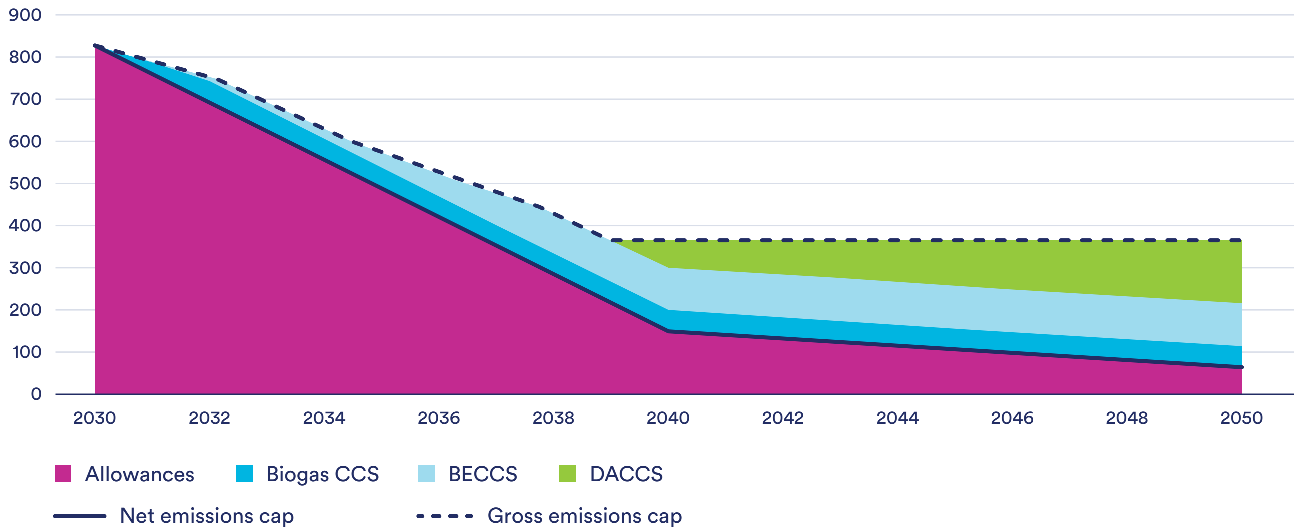
Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050 without restrictions, assuming lower marginal abatement costs than in the base analysis. Cost data for heavy industry behind the LIMES model are used as a proxy for the allowance price. Same maximum capacity limits are applied as in the base analysis, i.e. 50 million tonnes per year for biogas CCS, 100 million tonnes per year for BECCS, and no quantity limit for DACCS.

Figure A4: Emissions Cap under Direct Integration without Restrictions and Integration of Biochar



Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050 without restrictions and with the inclusion of biochar alongside biogas CCS, BECCS, and DACCS. The same maximum capacity limits are applied as in the base analysis for biogas CCS and BECCS, i.e. 50 million tonnes and 100 million tonnes per year respectively. As described in Appendix 1, biochar largely competes for the same biogenic resources as biogas CCS and BECCS in the model. However, it is assumed that some biogenic resources are exclusively used for BECCS due to considerations regarding CCS on Waste-to-Energy facilities.

Figure A5: Emissions Cap under Direct Integration without Restrictions and with Lower DACCS Costs (250 EUR per Tonne from 2040)



Note: The figure illustrates direct integration of permanent carbon removals into the EU ETS from 2030-2050 without restrictions, but assuming lower DACCS costs from 2040. In this scenario, DACCS costs are assumed to be 250 EUR per tonne from 2040 (rather than 335 EUR per tonne as in the base case). Same maximum capacity limits are applied as in the base analysis, i.e. 50 million tonnes per year for biogas CCS, 100 million tonnes per year for BECCS, and no quantity limit for DACCS.

APPENDIX 3

Literature Review on an Intermediary Institution

Proponents of creating an intermediary institution state the need for additional governance to manage the integration of carbon removals into the EU ETS due to the governance challenges that arise with integration, but also in some instances to manage the overall trajectory of the EU ETS to ensure the integrity and functioning of the system as it transitions towards net-zero and potentially net-negative emissions. Given that fundamental legislative amendments to the ETS Directive are required to integrate permanent carbon removals into the EU ETS, such an institution could be created or empowered within the process of that legislative change. The overall evolution of the concept of a intermediary institution within the context of the EU ETS are elaborated more in Box A1.

At one end of the spectrum, Edenhofer et al. (2023) envisions a relatively large mandate for the institution, wherein the institution would provide technical advice to the legislation process, manage a net emissions cap, organise the procurement of permanent carbon removals through reverse auctions and manage issues around non-permanence and liability with variable durability carbon removals, such as biochar. The proposal also calls for another two institutions to be created – a Carbon Removal Certification Authority and a Green Leap Innovation Authority.

Another policy proposal is that by Rickels et al. (2022, 2024), where an intermediary institution would also ensure the achievement of long-term climate targets by procuring carbon removals which would be placed into a carbon removal reserve or pool and then subsequently released into the EU ETS to ensure market stability, effectively functioning as a price containment reserve. Jeszke and Lizak (2024) propose that such an institution manages the flows of supply and demand of both emission allowances and carbon removals.

Some of the ideas draw parallels with central banks like the Federal Reserve or the European Central Bank, which regulate the money supply to stabilise economic conditions. However, establishing a ‘Carbon Central Bank’ or comparable institution would involve significant institutional challenges within the EU, particularly concerning the legal and political requirements needed for its creation. There are numerous hurdles associated with the development of such an independent institution. For example, the creation of a Carbon Central Bank, as proposed in some models, could in some instances necessitate a revision of the EU treaties, which is a process that demands unanimity among all Member States. A report in itself could be written on the different institutional designs, mandates, functions, and political considerations of creating a new institution to manage the EU ETS. For the purposes of this report and given the complexity of this issue, a narrow mandate is analysed in Section 3.4. Here, the focus is on the role of a potential institution acting as the intermediary between operators of permanent carbon removals and the EU ETS. Its primary role would be to procure permanent carbon removals, place them into a pool, translate the removal credits into allowances and manage their entry into the EU ETS. Setting up such an institution to manage carbon removals within the EU ETS could be achieved without the need for complex treaty changes, and the institutional set-up would most likely be carried out through amendments to the EU ETS.

Box A1: The Evolution of the Concept of a Intermediary Institution and International Examples[100]

The concept of an institution to manage compliance markets, most commonly termed a 'Carbon Central Bank' emerged particularly in the early 2000s as part of a broader discourse on improving market functionality and stability. The idea was proposed to address price volatility and unpredictability and its role was centred on its potential to act as a stabilising force akin to the role that financial central banks play in managing monetary policy.

The EU ETS has faced several challenges. In its early phases, the EU ETS experienced significant price volatility and, at times, severe price drops due to an oversupply of allowances. As such, some advocates for this proposal argue that a centralised institution could actively manage the supply of allowances in the market, purchasing excess allowances when prices were low and releasing them when prices were high, thus preventing extreme price fluctuations. Instead of establishing a Carbon Central Bank to manage price volatility and the surplus of allowances, the Market Stability Reserve (MSR) was agreed in 2015 as the solution to addressing the surplus of allowances and to improve the system's resilience to major shocks by adjusting the supply of allowances to be auctioned. The MSR is also used as a measure in the event of excessive price fluctuations.[101] The concept of the Carbon Central Bank has again risen to prominence in the context of integrating carbon removals into the EU ETS and managing the 'endgame' of the EU ETS.

Globally, various carbon markets have experimented with mechanisms to manage price stability and supply within their emissions trading systems. Besides the EU ETS, one such example is **Korea's ETS and the Allocation Committee**:

Korea's ETS incorporates an Allocation Committee that operates with a degree of discretion and is empowered to intervene in the market under specific conditions.

- The Allocation Committee can intervene if the allowance price exceeds three times the two-year average for six consecutive months, or if the price is double the two-year average for a month with trading volumes twice the historical average. It can also intervene if the price drops below 40% of the two-year average or if there is a supply-demand imbalance.
- Possible interventions include releasing allowances from a reserve, adjusting borrowing limits, or modifying the use of offsets.

The Korean ETS provides an example of how a body has been tasked with managing both price stability and liquidity through predefined rules while retaining some ability to act dynamically.

100 See: Brunner et. al (2012), Brookings Institution (2013), Baran (2016).

101 Under the EU ETS1, 75 million allowances shall be released from the market stability reserve, if the average allowance price for the six preceding calendar months is more than 2.4 times the average allowance price for the preceding two-year reference period.