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POLICY BRIEF

Bioenergy with Carbon Capture and Storage in the EU – Challenges and Opportunities

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1. Scope and Objectives

The report examines Bioenergy with Carbon Capture and Storage (BECCS) in the European Union context, focusing on its potential role in meeting climate targets and the associated challenges and opportunities for implementation.

The scope of this report encompasses:

1. Policy landscape analysis within the EU framework, particularly the Carbon Removals Certification Framework (CRCF), Renewable Energy Directive (RED), and potential integration with the EU Emissions Trading System (EU ETS).
2. Challenges in the deployment in the EU:
    - Technical and infrastructure limitations
    - Regulatory and financial barriers

The report aims to:

1. Evaluate the role of BECCS in reaching the EU's climate targets, particularly in light of the European Commission's 2040 climate target recommendation and IPCC projections
2. Identify key barriers to BECCS deployment at scale within the European context.
3. Assess the adequacy of current EU policy frameworks and propose policy recommendations for BECCS deployment in the EU.

This analysis is framed within the principle of technology neutrality established by the United Nations Framework Convention on Climate Change (UNFCCC), recognizing that a diverse toolbox of solutions, including carbon dioxide removal technologies like BECCS, will be necessary to achieve the Paris Agreement's objectives.

2. Introduction

2.1. Background

The analytical framework for this discussion is grounded in Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), which articulates the overarching objective of the international climate regime: namely, the stabilization of atmospheric GHG concentrations at levels that would avert dangerous anthropogenic disruption of the climate system. This provision establishes a clear outcome-oriented mandate, serving as the conceptual cornerstone for subsequent policy development and implementation within the global climate governance architecture.

Within this context, the principle of technology neutrality is implicitly embedded in both the UNFCCC and its derivative instruments. Article 2 delineates a goal-based approach, focusing on the stabilization of GHG concentrations without mandating or privileging specific technological interventions or methodologies. This structural flexibility enables Parties to the Convention to determine and deploy mitigation and adaptation strategies that are optimally tailored to their unique national circumstances, capabilities, and priorities.

The Paris Agreement operationalizes this technology-neutral ethos by explicitly promoting the development and transfer of technologies for both mitigation and adaptation purposes. It underscores the importance of fostering innovation and facilitating the diffusion of a diverse array of technological solutions, while deliberately refraining from endorsing or prescribing any particular technology. This approach is designed to catalyze broad-based participation and maximize the effectiveness of collective efforts to address climate change, in accordance with the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC).

2.2. The need for CDR

The Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) emphasizes the necessity of CDR to achieve global climate goals. The deployment of CDR methods and their levels in mitigation pathways vary based on assumptions about costs, availability, and constraints.

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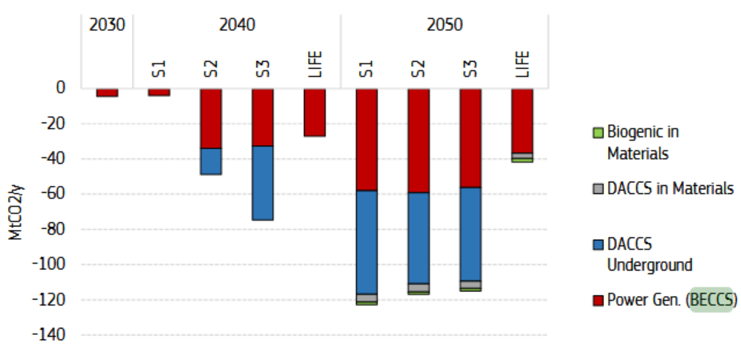
The European Commission's recommended 2040 climate target calls for a 90% reduction in net greenhouse gas emissions compared to 1990 levels. To achieve this, the Commission's modelling assumes a significant role for permanent carbon removals, specifically through DACCS and BECCS. According to the Commission's impact assessment, by 2040, permanent carbon removals are expected to deliver up to 75 Mt of CO2 annually—33 Mt from BECCS and 42 Mt from DACCS. The projections for DACCS and BECCS combined range from as low as 16 MtCO2 (in the S1 scenario) to as high as 155 MtCO2 (in the S3 scenario), which would account for approximately 0.3% to 3.3% of the EU's total 1990 greenhouse gas emissions (Impact assessment Accompanying the 2040 Communication from the European Commission)[1]

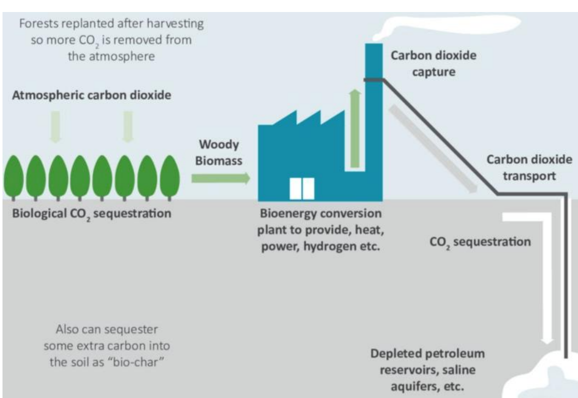
Figure 2: Carbon removals by source and use



The Sustainable Carbon Cycles Communication, referenced in the Commission's 2040 Communication, emphasizes the need for both natural and technological removals to reach climate neutrality. It sets out a vision for scaling up high-quality carbon removals, including a goal of achieving at least 5 MtCO2 per year from industrial removals (such as DACCS and BECCS) by 2030, with a view to much larger volumes by 2040 and 2050 as part of the EU's net-zero pathway.

2.3. Introduction to BECCS

The BECCS combines biomass energy production with carbon capture and storage (CCS) to achieve negative emissions. The process begins with the cultivation of biomass feedstocks, such as fast-growing crops, agricultural residues, or forestry waste, which absorb atmospheric CO_2 during photosynthesis. When this biomass is used for energy production the carbon stored in the biomass is released as CO_2. Instead of being emitted into the atmosphere, the CO_2 is captured. The captured CO_2 is then compressed, transported via pipelines or ships, and permanently stored in geological formations such as depleted oil and gas reservoirs, saline aquifers, or deep basalt formations[2].

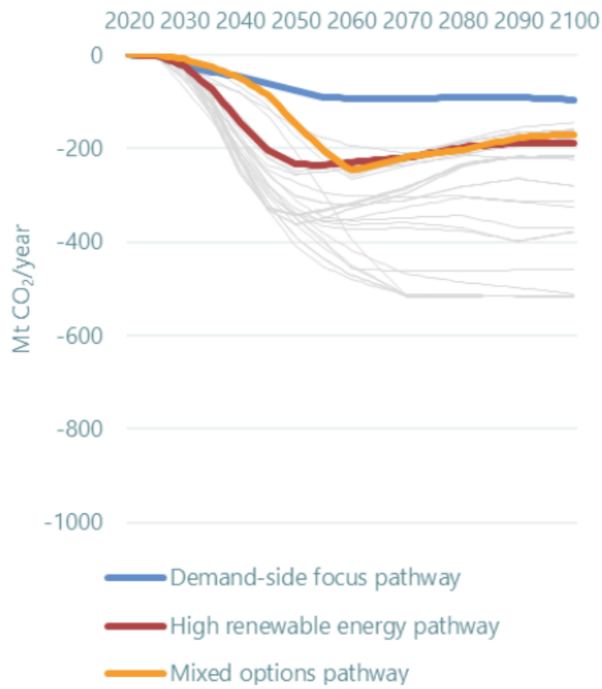


The emissions negativity in BECCS originates from the biological carbon cycle rather than direct atmospheric extraction. Upon combustion for energy generation, this biogenic carbon would normally return to the atmosphere, creating a carbon-neutral cycle. However, BECCS intercepts this return flow by capturing the CO_2 at the

[1] Source: Impact assessment Accompanying the 2040 Communication from the European Commission
[2] Source: Princeton 2020

point of combustion and permanently storing it underground or in other geological formations. This intervention creates net atmospheric removal because the carbon that was initially absorbed from the atmosphere never completes its return journey, effectively removing it from the active carbon cycle.[3]

BECCS is featured non-negligibly in Integrated Assessment Models used to project pathways for limiting global warming to 1.5°C or 2°C[4]. Its dual function – energy production and permanent carbon storage – makes it a versatile tool in scenarios where residual emissions from hard-to-abate sectors persist. For instance, Zhao et al. 2024 calculates that, in scenarios with more stringent climate targets (i.e., lower carbon budgets for 1.5°C), removals from land-based CDR increase by 200–230 $GtCO_2$ compared to 2°C scenarios, with over 90% of the additional removal coming from BECCS.



3. BECCS in the EU

3.1. Regulatory Framework

No comprehensive treatment of the covered legislative instruments is provided. Instead, our focus remains exclusively on those specific provisions that substantively impact BECCS policy.

3.1.1. Carbon Removals Certification Framework (CRCF)

The CRCF, adopted in December 2024, establishes the first EU-wide voluntary certification system for carbon removals, including BECCS and other technologies like DACCS. BECCS is classified under "Permanent Carbon Removal" within the CRCF, alongside DACCS and biochar.

[3] The technical mechanism relies on the temporal displacement between carbon uptake during biomass growth and the prevented release during energy production. The negativity, then, is contingent upon the carbon accounting framework that treats the initial atmospheric absorption as a given baseline, with the capture and storage representing an additional intervention that breaks the natural cycle. For instance, DACCS (Direct Air Capture and Carbon Storage) differs fundamentally because it achieves intrinsic negativity through immediate atmospheric extraction without relying on biological intermediates.

[4] Source: ESABCC 2023

The framework sets QU.A.L.ITY criteria (Quantification, Additionality, Long-term Storage, Sustainability) to ensure environmental integrity.

- **Quantification**: Activities must demonstrate a net carbon removal benefit calculated using standardized baselines or activity-specific baselines, with conservative accounting for uncertainties.
- **Additionality**: Activities must go beyond statutory requirements and rely on certification incentives for financial viability.
- **Long-term Storage**: For BECCS, permanent storage (several centuries) must be verified through monitoring rules aligned with Directive 2009/31/EC – i.e. the CCS Directive - for geological storage and liability mechanisms to address reversals.
- **Sustainability**: Activities must do no significant harm to environmental objectives (e.g., biodiversity) and generate co-benefits.

The CRCF mandates that methodologies for each activity (including BECCS) be developed as Delegated Acts, which will become legally binding. These methodologies must detail robust conditions for certification, including monitoring, liability, and sustainability rules and prioritize mature activities with high co-benefits.

3.1.2. Renewable Energy Directive (RED)

It is worth noting that RED's treatment of BECCS remains implicit rather than explicit. The Directive does not directly regulate BECCS as a technology, nor does it define carbon removals within its core provisions. Nevertheless, through its detailed biomass governance provisions, RED establishes a *de facto* regulatory framework that determines which BECCS pathways are viable and supportable within the EU, especially given the critical role of biomass sustainability and eligibility criteria.

RED mandates that biomass used for energy must comply with the following sustainability requirements:

- It must not originate from ecologically sensitive areas, including (i) primary forests, old-growth forests, and highly biodiverse ecosystems (e.g., wetlands, peatlands, heathlands), (ii) and with high carbon stock, such as undrained peatlands or forests with significant soil carbon reserves, and (iii) agricultural land designated for nature protection under EU or national laws;
- Maintenance of forest carbon stocks and biodiversity through sustainable harvesting practices;
- Biomass energy pathways must demonstrate minimum GHG savings relative to fossil fuels:

Fuel Type	GHG Savings Threshold	Calculation Methodology
Advanced Biofuels	≥70%	Lifecycle analysis (LCA) per Annex V of RED II
Solid/gaseous biomass (post-2021 installations)	≥70% (rising to 80% by 2026)	Default values (Annex VI) or actual pathway analysis
Waste/residue-based fuels	Exempt from sustainability criteria but still subject to GHG thresholds.	

Economic operators may use default emission values or project-specific calculations incorporating cultivation, processing, and transport emissions. Compliance is verified through certification schemes audited by the European Commission, such as PEFC RED II or ISCC.

At the core of RED's biomass policy is the cascading use principle, which aims to achieve the resource efficiency of biomass use by prioritizing, wherever possible, the material use of biomass over its energy use, thus increasing the amount of biomass available within the system. The main argument used for this priority scale is to avoid locking high-value biomass into relatively low-efficiency energy applications—an issue directly relevant to BECCS, which can relies on combustion of wood pellets or other woody biomass.

This has potentially relevant implications for methodology development. BECCS is not merely about producing energy, but also about co-producing carbon removals. The argument can be made that the methodology recognizes that co-producing carbon removals and energy delivers significantly different economic and environmental value compared to energy production alone. Any translation of the cascading hierarchy to carbon removal certification, or to member state derogations on feedstock eligibility, should therefore rely on robust comparative LCA of wood fiber use when determining effective cascading. This includes evaluating the carbon intensity of the product, the carbon intensity of substituted products, and the duration of product carbon storage. It is worth mentioning that recent studies - undergoing critical review and verification against ISO14067- on the comparative carbon footprints of uses of wood residues and low-grade roundwood demonstrate suggest that BECCS and bioenergy are among the best uses of (low grade) wood feedstocks for delivering climate benefits (see Gaudreault 2025)[5].

[5] According to the lifecycle assessment results presented in the report, among all considered uses of forest residues, BECCS provides the greatest climate benefits, followed by unabated bioenergy, and then biochar. For manufacturing residues and pulpwood, OSB provides the greatest climate benefits, followed by BECCS, then bioenergy. The report highlights that BECCS ranks as the best or second-best option for delivering climate impact across all considered feedstocks. While unabated bioenergy shows a lower climate impact than BECCS, it still delivers greater climate

RED imposes several restrictions on the types of biomass eligible for public support, which contribute to shaping the economics of BECCS deployment. Member States are explicitly prohibited from granting direct financial support for the production of energy from saw logs, veneer logs, industrial-grade roundwood, stumps, and roots[6]. The rationale behind this prohibition, stated in the Directive, is to prevent unsustainable practices and to avoid creating perverse incentives that could increase competition with material uses of biomass or threaten forest carbon sinks. However, at this stage, it is still unclear if the application of Article 3 of RED (i.e., cascading principle and feedstock restrictions related to direct financial support for energy production) will be extended to the BECCS methodology under the CRCF.

The application of Article 3 could also have some unintended consequences in terms of feedstock exclusion:

- Broadly applying RED III feedstock exclusions to BECCS could unintentionally exclude sawmills and pulp mills from participating in carbon removal crediting, even when their CO_2 streams come from integrated processes that use a variety of fibre types listed in the restrictions;
- There could also be contradictions regarding biofuels: while certain ligno-cellulosic biomasses are incentivized for advanced biofuel production under RED III (Annex IX Part B), applying Article 3 restrictions to BECCS could prevent carbon removals from being generated from these same feedstocks, despite their eligibility for advanced fuels.

RED treats biogenic CO_2 emissions as zero-rated[7], based on the idea that the CO_2 released during biomass combustion is reabsorbed as new biomass grows, thus cycling carbon through the atmosphere and biosphere rather than adding fossil carbon to the system.

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benefits than some other pathways, such as SAF and pulp and paper, and similar benefits to biochar. These rankings were found to be insensitive to geographical context (US versus Europe), indicating that the benefits of BECCS and bioenergy persist even with long-distance transportation of feedstocks

[6] Article 3 notes that *"Member States shall not grant direct financial support for the use of saw logs, veneer logs, industrial grade roundwood, stumps and roots to to produce energy"*. The CRCF, conversely, concerns the certification of carbon removals. Accordingly, it may be inappropriate to directly infer that this financial support restriction should automatically apply to the certification of carbon removals from BECCS. Further research and clarification are needed before considering the extension of these specific feedstock exclusions to BECCS certification. There is a perspective that the application of Article 3's restrictions to BECCS certification may not be appropriate.

[7] The following technical requirements are included: (1) the biogenic CO_2 must originate from the combustion or processing of biofuels, bioliquids, or biomass fuels that are themselves certified as sustainable. The RED distinguishes between agricultural biomass, forestry biomass, and waste/residue streams, each with specific eligibility and sustainability requirements; (2) The life cycle assessment (LCA) or well-to-wheel (WtW) methodology must be applied, ensuring that all emissions from cultivation, harvesting, processing, transport, and conversion are included.

The CRCF is designed to align with the sustainability rules set out in Article 29 of the RED (including RED II and RED III), which define the minimum sustainability and GHG emission criteria for biomass and bioenergy feedstock[8]. More precisely, the CRCF uses these RED sustainability criteria as a baseline, meaning that any feedstock or project must at least meet these requirements to be considered eligible.

3.1.3. Regulation on Land Use, Land Use Change, and Forestry (LULUCF)

The EU's Land Use, Land Use Change and Forestry (LULUCF) Regulation (Regulation (EU) 2018/841) establishes the legislative framework for emissions and removals from the land use sector for 2021-2030. In essence, the LULUCF Regulation provides the accounting framework for the biogenic carbon removals achieved through biomass cultivation, which forms the "Bioenergy" component of BECCS. The subsequent capture and storage of CO_2 emissions from the bioenergy conversion process falls under different regulatory mechanisms – the EU ETS[9].

The overarching "no-debit" rule requires Member States to ensure that accounted emissions do not exceed accounted removals from land use. This means that any net emissions arising from land-use changes to establish bioenergy plantations (e.g., conversion of high-carbon stock land) would need to be offset by additional removals within the LULUCF sector. Complementarily, the Renewable Energy Directive (RED III) in Article 29(7) also mandates that *"systems are in place at forest sourcing area level to ensure that carbon stocks and sinks levels in the forest are maintained, or strengthened over the long term."*

The LULUCF Regulation sets an EU-level net removal target of 310MtCO_2 by 2030, as compared to the 2016-2018 average.

3.1.4. EU Emissions Trading System (ETS) Directive

Only if the net GHG emissions savings meet or exceed the mandated threshold can the biogenic CO_2 be considered carbon-neutral; (3) Biomass feedstocks associated with high indirect land use change (ILUC) risk are restricted or capped. Only certified "low ILUC-risk" biofuels may count towards renewable energy targets, and by 2030, high ILUC-risk feedstocks are excluded from the carbon-neutral classification; (4) the biogenic CO_2 must not have previously received emissions credits for carbon capture, utilization, or replacement under other regulatory mechanisms. This prevents double counting of GHG reductions. (5) If the biomass is derived from waste streams, the waste hierarchy (as per Directive 2008/98/EC – i.e. the Waste Framework Directive) must be followed, prioritizing material recovery before energy recovery, and only using waste not suitable for recycling.

[8] There is ongoing discussion about whether CRCF should require even stricter criteria or additional safeguards, especially regarding biodiversity and broader sustainability impacts, but the RED standards are the foundational minimum. See, for example, Searchinger et al. 2018.

[9] For a detailed summary of the provision, see Oko Institut 2021.

The EU Emissions Trading System is the European Union's primary cap-and-trade mechanism for reducing greenhouse gas emissions from power generation, industry, and aviation. It operates by setting a declining cap on total emissions and issuing allowances, which entities must surrender to cover their emissions. Currently, the EU ETS does not recognize or include carbon removal - such as those from BECCS – as a compliance instrument, meaning that companies cannot use negative emissions to offset their obligations under the system. Arguments typically used by the European Commission for the current exclusion include account integrity preservation and mitigation deterrence.

Future revisions to the EU ETS, including a 2026 review, could redefine compliance pathways. If CDR integration proceeds, mechanisms may include[10]:

- Dual targets for emissions reductions and removals;
- Adjustments to the cap by introducing a net-negative emissions budget post-2040.

3.2. Case Study: the BECCS Stockholm Project

The BECCS Stockholm project, led by Stockholm Exergi, is a large-scale BECCS initiative at the Värtan bio-cogeneration plant in Stockholm, Sweden. The facility aims to capture up to 800,000 tonnes of CO_2 annually from biomass combustion, a volume greater than the total emissions from Stockholm's road traffic each year, making it one of the largest negative emissions projects globally (EIB, 2025). The plant uses forestry and sawmill residues-such as wood chips, branches, and treetops-as its feedstock, ensuring that captured CO_2 is biogenic and thus results in net carbon removals. The facility will use Capsol Technologies' carbon capture solution, which features inherent heat recovery and is based on proven solvent technology. Heat recovered from the capture process will be fed into Stockholm's district heating network. The captured CO_2 will be liquefied and stored permanently in sedimentary bedrock beneath the North Sea. This project has secured an agreement with Microsoft for the removal of 500,000 tonnes of CO_2 per year, marking the largest engineered carbon removal deal globally.

On March 27, 2025, Stockholm Exergi and its shareholders made the final investment decision to proceed with the BECCS project. The European Investment Bank (EIB) granted a €260 million loan, its first for a carbon capture project, supporting SEK 13 billion (approx. €1.1 billion) investment (EIB, 2025). The project is also backed by €180 million from the EU Innovation Fund and private purchases of negative emission certificates.

3.2.1. Crediting Mechanism

[10] A more detailed exploration of the options can be found in ESABCC 2025, ERCST 2024, 2025 (forthcoming).

The BECCS Stockholm project operates a crediting mechanism whereby the quantity of CO_2 removed from the atmosphere is monitored, reported, and verified according to emerging CDR certification protocols. For each verified tonne of CO_2 sequestered, a corresponding carbon removal certificate (CRC) is issued.

These certificates are sold to corporate buyers, such as Microsoft, on the voluntary carbon market. Companies use the CRCs to offset their own greenhouse gas emissions for the purposes of meeting self-imposed net-zero or climate neutrality targets. In practice, companies can buy carbon CRC corresponding to 1 tonne of carbon removals per CRC. In line with the policy of the Swedish government, the carbon removals exchanged in this agreement will be used by Microsoft to negate its own emissions and will be transparently reported as fitting under Sweden's climate targets, similarly to how corporate emission reductions contribute to national climate targets (see BECCS Stockholm 2025). In terms of accounting, the carbon removals will be accounted outside the sum of Scopes 1 to 3 as neutralization of residual emissions in a company's value chain.

4. Challenges

BECCS, as an engineered CDR technology, presents challenges across multiple dimensions. Many of these challenges are technology-specific, applying regardless of deployment location. These include technical limitations in capture technologies efficiency, etc.

Another set of challenges, however, is specifically relevant to the EU context—dependent on, and shaped by the Union's regulatory framework, biomass policy, Member States' priorities, etc. This report focuses primarily on these EU-specific challenges.

4.1. Lack of Integration with the EU ETS

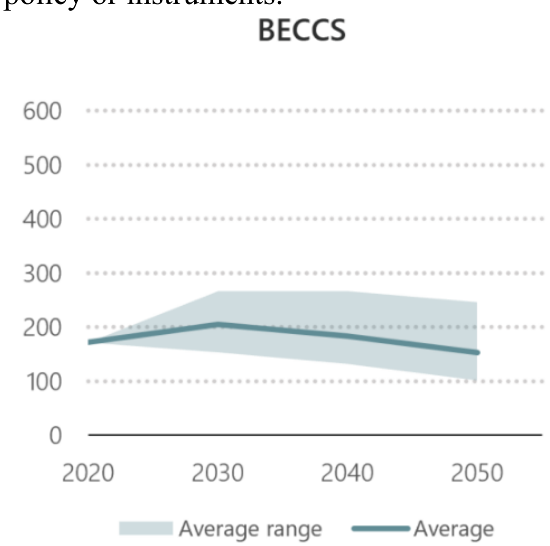
The EU ETS is currently set up and reduce emissions, not reward removals. BECCS creates net atmospheric carbon removal by intercepting biogenic CO_2 that would otherwise return to the atmosphere during biomass combustion and diverting it to permanent geological storage, thereby breaking the natural carbon cycle and preventing the completion of carbon's atmospheric return journey. However, under existing EU ETS rules, biogenic CO_2 emissions are considered "carbon neutral" (emission factor = 0), meaning capturing and storing them does not yield tradable credits or financial rewards (see, for example, Nehler and Fridahl 2022). Without a mechanism to monetize negative emissions, BECCS projects lack a revenue stream to capital and operational costs – e.g. CCS infrastructure, biomass supply chains, etc[11].

[11] It is conceptually possible to establish a parallel market for carbon removals, with or without the possibility of gradually linking it to the EU ETS as the EU moves toward climate neutrality. However, mainly for credibility reasons, the integration with the EU ETS may be preferable (See, among others, ERCST 2024 & ERCST forthcoming).

4.2. Carbon Price Mismatch

Even if BECCS were fully integrated in the EU carbon trading system, current EU Allowance (EUA) prices (~€50–100/tCO_2) would be insufficient to incentivize it, given its current estimated costs of €100–200/tCO_2[12][13][14].

This means that the revenue from selling EUAs would not cover the full cost of BECCS deployment, leaving a substantial funding gap, which should be filled by additional financial policy or instruments.



Carbon Contracts for Difference (CCfDs) are under consideration as a policy tool to bridge the funding gap for BECCS and other high-cost carbon removal or abatement technologies. Technically, a CCfD guarantees a fixed carbon price for project developers over a specified period. If the market carbon price (e.g., EU ETS price) falls below this guaranteed level, the government pays the difference; if it rises above, the developer pays back the surplus. This mechanism can help stabilize the revenue stream

[12] Source: EUA Futures, ICE.
[13] A comprehensive summary of cost estimates is provided, among others, by Abegg et al. 2024.
[14] Source: ESABCC 2025 elaboration of Abegg et al. 2024, which outlines the potential cost trajectory of BECCS based on expert elicitation.

by hedging against carbon price volatility and bridge the funding gap.

4.3. Eligibility of Biomass Use for Energy under RED

RED, particularly through its incorporation of the cascading use principle and stringent sustainability criteria for biomass utilization, imposes significant constraints on the potential scale of BECCS deployment within the European Union. Since BECCS relies on a consistent and scalable supply of sustainable biomass, the prioritization of biomass for material uses and the exclusion of certain feedstocks from the energy sector directly constrain the achievable scale of BECCS deployment in the EU context.

5. Recommendations

5.1. Integration of BECCS in the EU ETS

BECCS should be formally recognized as a compliance instrument within the EU ETS. Accordingly, the EU would need to amend the ETS Directive to allow regulated entities to use verified, permanent carbon removals from BECCS to meet part of their compliance obligations. This would create a direct market incentive for BECCS deployment by enabling the use of BECCS-derived removal credits for surrendering allowances, similar to how captured and geologically stored CO_2 from fossil sources is currently treated.

Integration of BECCS requires the development and enforcement of robust MRV protocols to ensure environmental integrity, permanence, and the avoidance of double counting. The EU's Monitoring and Reporting Regulation (MRR, Regulation 2018/2066) already provides a framework for reporting and verifying CO_2 emissions and removals, including from CCS activities. For BECCS, MRV protocols would need to:

- Quantify net-negative emissions, accounting for the full lifecycle of biomass (cultivation, harvesting, transport, processing, and conversion to energy).
- Require independent, third-party verification of removal claims, as set out in the proposed CRCF Regulation.
- Align with the QU.A.L.ITY criteria: Quantification, Additionality, Long-term storage, and Sustainability.

Furthermore, guarantees are required that any integration incorporates quantitative and qualitative constraints to prevent unsustainable biomass sourcing and safeguard forest carbon sinks:

- While some propose quantitative safeguards, such as caps on the volume or share of BECCS-derived removal credits eligible for compliance, an alternative perspective is that projects should be assessed on a case-by-case basis. This approach would rely on strict accounting rules to ensure that only net-negative emissions, after accounting for lifecycle emissions (including cultivation, harvesting, transport, and processing of biomass), are credited. Existing legislation such as RED, the LULUCF Regulation, and the methodologies to be developed under the CRCF are considered by some to provide sufficient safeguards without the need for overarching quantitative restrictions defined in policy or legislation.
- Qualitative safeguards should be primarily ensured through the application of sustainability criteria for biomass feedstocks, as already mandated by RED and to be further detailed in the specific methodologies developed under the CRCF.

5.2. LCA Approach in BECCS Methodology and RED Iterations

Further iterations of RED and BECCS' methodology must be fully based on a rigorous and comprehensive accounting of all greenhouse gas (GHG) emissions and removals associated with the entire BECCS value chain. To ensure environmental integrity and the credibility of reported net-negative emissions, it is essential that the assessment framework adopts a genuine life cycle assessment (LCA) methodology, as defined by internationally recognized standards such as ISO 14040/44 and the IPCC Guidelines[15]. A robust LCA-based BECCS methodology should systematically quantify both direct and indirect GHG fluxes, encompassing all stages from biomass production to permanent CO_2 storage. This includes the transport of the feedstock, manufacturing processes, transport to customer/client, use of the product, and final disposal. In the case of energy use, the system boundaries finish at the point of energy production. The scope of the LCA must extend beyond the boundaries of the BECCS facility itself, capturing upstream and downstream processes, as well as potential system-wide effects.

5.3. Bridge the Carbon Price Mismatch for Early Movers

The transitional implementation of additional financial policies and instruments for early movers may be desirable to cover the funding gap and accelerate market uptake. CCfDs are under

[15] It is worth noting that industry has already moved in this direction. For example, Drax, together with EcoEngineers and Stockholm Exergi, has developed a Carbon Dioxide Removal (CDR) Methodology incorporating full life-cycle emissions and external leakage impacts. This methodology aligns with the Integrity Council for the Voluntary Carbon Markets (ICVCM)'s Core Carbon Principles, ensuring robust quantification, transparency, and independent third-party validation and verification, crucial for establishing high-integrity carbon credits that can be recognized in carbon markets or policy frameworks such as the EU ETS. See Drax and Stockholm Exergi 2024.

consideration as an appropriate funding instrument to mitigate the risk and bridge the gap. While these instruments may be functional to bridging the cost gap, they could also indirectly distort the carbon price signal.

If such measures are deemed necessary to accelerate CDR deployment, they should be designed as temporary, transitional tools that do not undermine the long-term functioning of the carbon market in the EU, whose primary function is to ensure that the most cost-effective abatement options are prioritized across the economy. The following two conditions, then, should be met in the design phase:

- *Temporality*: mechanisms like CCfDs should be explicitly time-bound, with clear sunset clauses or phase-out criteria linked to market maturity or cost thresholds;
- *Project-Specificity*: financial support instruments should target specific early-mover projects rather than entire sectors, minimizing market distortion and government exposure.

The development of public purchasing programs for certified carbon removals could also play a role in stimulating early-stage project development and providing revenue certainty for pioneering BECCS facilities. The European Commission's DG CLIMA is exploring options for an EU purchasing program for permanent CDR to address a critical gap in climate change mitigation, as part of the initiative titled *"Strategy for the Financing of Permanent Carbon Removals"* which runs from September 2024 to August 2025. Design aspects of such program - e.g. mandate, portfolio, purchasing methods, additional services, and funding - are still under discussion (McDonald et al. 2025).