

Bridging the CDR funding gap: policy choices and design options

Andrei Marcu

Marino Varricchio

Chiara Cavallera



Contents

Understanding the CDR Funding Gap in the EU	2
Scale of the Funding Gap	2
Current Financing Landscape	5
Funding Options Analysis.....	8
Carbon Contracts for Difference	8
Public Purchasing Programmes	12
Voluntary Markets	14
Offtake agreements	16
Integration in Compliance Mechanisms.....	18
Design Options Analysis for a CDR finance architecture	20
CDR Methods and Funding Eligibility Criteria	20
Technology Neutrality vs. Strategic Prioritization.....	21
Policy Recommendations.....	22

Understanding the CDR Funding Gap in the EU

Scale of the Funding Gap

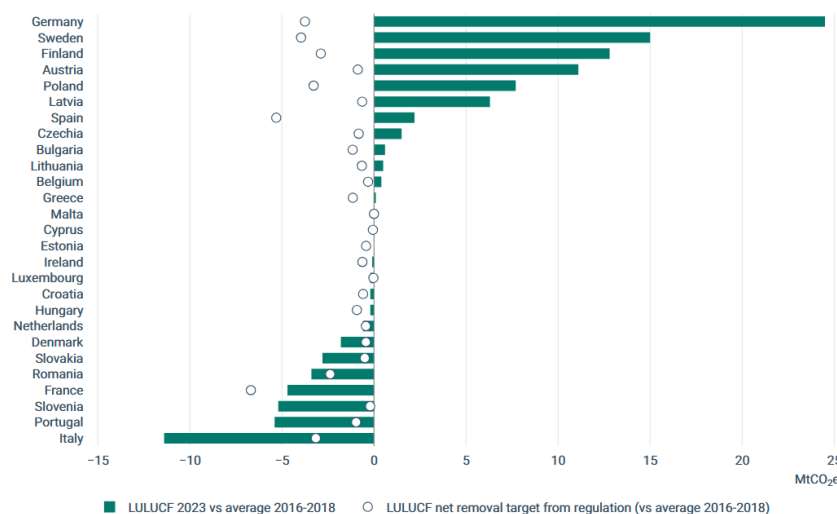
The European Union's need for a rapid scale-up of CDR is now anchored in both scientific assessment and EU policy advice. The ESABCC concluded that, to deliver on climate-neutrality trajectories, the EU will likely need to remove on the order of 400–800 million tonnes of CO₂ per year by mid-century¹. This scale is consistent with the IPCC's AR6 synthesis: most 1.5–2°C-consistent scenarios rely on substantial CDR to reach or overshoot net-zero CO₂ at the global level, meaning removals must play a role alongside emissions cuts².

¹European Scientific Advisory Board on Climate Change. (2025, February 21). *New report outlines recommendations to scale up carbon dioxide removals while addressing opportunities and risks*. <https://climate-advisory-board.europa.eu/news/new-report-from-the-eus-climate-advisory-board-outlines-recommendations-to-scale-up-carbon-dioxide-removals-while-addressing-opportunities-and-risks>

²Intergovernmental Panel on Climate Change. (2022). *Chapter 12: Cross-sectoral perspectives*. In P. R. Shukla, J. Skea, R. Slade, A. Al Khoudrajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasijsa, G. Lisboa, S. Luz, J. Malley (Eds.), *Climate change 2022: Mitigation of climate change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-12/>



While demand for engineered and enhanced removals is rising, the LULUCF sink that historically offset a material share of emissions has weakened. Recent EEA analyses and the Commission's Joint Research Centre document a fall in net LULUCF removals: the land sink removed about 198 MtCO₂e in 2023 and, on average over 2014–2023, was some 30% smaller than in the prior decade, driven by ageing forests, higher harvest rates and increasing natural disturbances linked to climate change³. That declining natural capacity increases the pressure on engineered and managed removals to fill the gap.



Despite this converging technical and policy imperative, there is a persistent and substantial financing shortfall. Carbon Gap's consolidated review of EU-level research and innovation instruments estimates that between 2020 and 2023 the

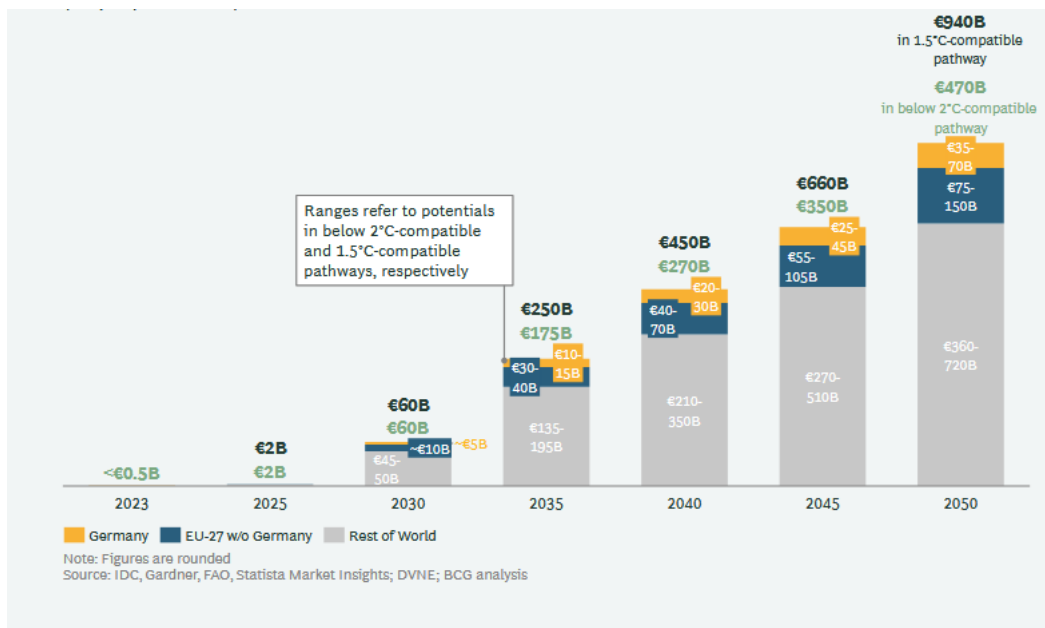
Net LULUCF removals in 2023 compared to the 2016-2018 average. Source: EEA

EU (excluding national support) directed roughly €657 million to programmes that explicitly support CDR methods, primarily through Horizon Europe, the Innovation Fund and related calls, and that this represents a tiny fraction (reported as under 0.1%) of the EU's projected climate action budget for the 2021–2027 cycle⁴. That mismatch between the scale of the scientific need and the scale of public support is visible when compared with even conservative industry and modelling projections of the sector's future size, which estimate that a mature European CDR sector could be worth on the order of €220 billion per year by 2050 and support as many as 670,000 jobs⁵.

³European Environment Agency. (2025, June 30). *Europe's land carbon sink declines, but its potential stays high*. <https://www.eea.europa.eu/en/newsroom/news/europes-land-carbon-sink-declines-but-its-potential-stays-high>

⁴Carbon Gap. (2025, February 20). *Rising to the challenge: Funding CDR research, development & innovation for a net-zero competitive EU*. <https://carbongap.org/rising-to-the-challenge-funding-cdr-research-development-innovation-for-a-net-zero-competitive-eu>

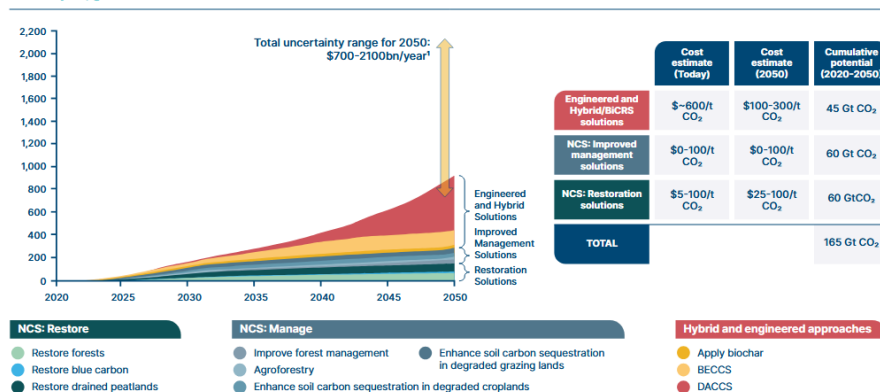
⁵Deutscher Verband für Negative Emissionen e.V. (DVNE) & Boston Consulting Group. (2024, June 1). *Carbon dioxide removal: Europe and Germany's role in catalyzing a trillion-euro industry*. https://cms.think-negative.org/uploads/240620_dvne_bcg_cdr_economic_potential_en_vfinal_180dpi_b4aa840efcaf_1754461b25.pdf



CDR-induced economic potential by region. Source: DVN & BCG.

Independent costing and road-mapping work attempts to quantify how much extra public R&D and demonstration funding is necessary to move a portfolio of CDR options up the maturity curve. Carbon Gap's analysis, synthesising grant flows, TRL gaps and cross-cutting research needs, estimates that bridging the EU's near-term development shortfall for a diversified CDR portfolio will require directing roughly €2.88–5.85 billion over the

Expected annual cost of CDR solutions
USD bn/year, global



Required Annual CDR Investment Flows to Close the Global Gap. Source: Energy Transitions Commission. Mind the Gap: Closing the CDR Funding Gap.

measurement and environmental trade-offs. That number is purposefully limited to the public-good, pre-commercial elements of the value chain; additional capital will be required

next 15–20 years toward technical development, pilot demonstration, shared infrastructure for transport and storage, and the science needed to resolve verification, meas-



later for scale-up, industrial deployment and the co-development of CO₂ transport and storage networks⁶.

The need for public financing is not only about research grants. CCS, an enabling infrastructure for long-lived engineered removals such as BECCS and DACCS, faces its own revenue and capital shortfalls. Analyses by Clean Air Task Force, Carbon Limits estimate a cumulative funding gap on the order of €10 billion for announced CCS projects through 2030 if predictable revenue streams and co-financing are not put in place; without such support, projects that depend on early-stage carbon-offtake revenues and extensive transport/storage investments will struggle to proceed⁷.

Technologically and economically, different CDR pathways present highly heterogeneous risk-return profiles. Nature-based approaches are relatively low-cost per tonne today and provide notable co-benefits, but they face reversibility and permanence risks and are constrained by land availability and competing uses. Engineered removals can achieve long-lived storage when paired with verified geological sequestration but currently exhibit higher capture costs and, in many cases, lower TRLs; Emerging methods such as ERW and biochar have different technical footprints and co-risks, which is why public investment that targets measurement and life-cycle accounting are essential before large-scale deployment.

In short, scientific assessments, EU advisory bodies and independent analysts converge on four linked conclusions: first, significant CDR volumes will be needed to meet Europe's climate goals; second, the EU's natural sink is weakening, increasing the scale and urgency of engineered removals; third, current EU-level public funding is small relative to the development and early demonstration resources experts judge necessary and fourth, closing these gaps will require a package of public interventions that combine R&D, market-creation (including public procurement and demand guarantees), and infrastructure finance to mobilize subsequent private capital, while simultaneously embedding strong MRV and social-environmental safeguards.

Current Financing Landscape

The EU's current CDR financing architecture is uneven and under-scaled for the deployment task ahead: public support is concentrated in early research and a handful of large

⁶ Carbon Gap. (2025, February 20). *Rising to the challenge: Funding CDR research, development & innovation for a net-zero competitive EU*. <https://carbongap.org/rising-to-the-challenge-funding-cdr-research-development-innovation-for-a-net-zero-competitive-eu>

⁷ Clean Air Task Force & Carbon Limits. (2021, December 14). The gap between carbon capture and storage ambitions and available funding. https://cdn.catf.us/wp-content/uploads/2022/01/12061446/CarbonCapture_FundingGap_Paper_Proof_12.14.21.pdf



demonstrations, while the mid-stage validation and early commercial scale-up that typically sit at Technology Readiness Levels 6–8 remain poorly covered. As we have seen, the Union directly channelled only on the order of €657 million specifically to carbon-removal activities through centrally managed programmes.

At EU level, Horizon Europe (the central R&I framework) is the lead vehicle for upstream science and technology development; the programme's remit and reporting emphasize support for collaborative research, proof-of-concept and technology maturation across low TRLs. The European Innovation Council (Pathfinder, Transition, Accelerator) in practice targets the pathway from basic research to commercial demonstration (Pathfinder for TRL 1–4 and the EIC Accelerator/Transition instruments are explicitly designed to take promising projects into TRL 6–8 and beyond, yet its volume remains targeted at start-ups and SMEs rather than large infrastructure roll-out). By contrast the Innovation Fund, financed from EU ETS revenues, is structured to underwrite large-scale demonstration and first-of-a-kind commercial projects: the Fund has mobilized multiple large calls and, by mid-2020s, had already committed several billion euros to more than a hundred net-zero projects.

Complementary EU instruments are present but small or narrowly focused. The LIFE program remains the EU's principal dedicated environment/climate grants instrument (2021–2027 envelope $\approx$ €5.4 billion) but its allocations for ecosystem-based removals and land practices are modest relative to the scale of removals that models imply will be needed, and CarbonGap's mapping treats the EU's direct CDR outlays as a fraction (around 0.1%) of the broader Green Deal investment ambition.

National programmes supplement EU funding but vary greatly in scale and instrument design, as examples below clearly show. Germany has recently placed CDR more visibly in the federal budget and through public banks and programmes: public reporting and press briefings in 2024–2025 indicate federal commitments approaching the mid-hundreds of millions for CDR activities (including support routed via KfW instruments and new industrial decarbonisation schemes), signaling significant but time-bound national support for pilots and early deployment of capture and storage in hard-to-abate sectors⁸. France's national "France 2030" investment plan (a €34 billion multi-year industrial strategy) explicitly identifies CCUS and related studies and pilot activities as priorities and has mobilized targeted calls for storage assessments and industrial decarbonisation

⁸Federal Ministry for Economic Affairs and Climate Action. (2023, June 7). *Launch of Green Transition Facility at KfW Capital: €100 million for venture capital funds in Germany and Europe to be invested in climate-tech startups*. <https://www.bundeswirtschaftsministerium.de/Redaktion/EN/Pressemitteilungen/2023/07/20230607-launch-of-green-transition-facility-at-kfw-capital.html>



schemes, including new CCUS support but the bulk of funding announced to date is focused on feasibility, cluster formation and subsidy schemes⁹.

Sweden has expanded programmes such as Klimatklivet and Industriklivet and in 2025 announced a sizeable re-authorization for these instruments, reflecting a national posture that couples grants for bio-based removals and industrial pilots with experimentation in procurement and public support for negative-emissions pathways; the Swedish Green Procurement and climate policy documents show active work to translate public purchasing power into climate outcomes that could be adapted for removals¹⁰. Sweden has also become a European frontrunner with its reverse auction system for BECCS, allocating up to SEK 36 billion (approx. €3 billion) from 2026–2046 for permanent storage. The 2024–2025 round saw Stockholm Exergi secure over SEK 20 billion (approx. €1.8 billion) for its large-scale BECCS facility, with support paid over 15 years, selected for lowest cost per tonne of storage. Remaining funds will be distributed in future rounds, and the scheme aims to fund both investment and operational costs for qualifying projects, with ongoing evaluation for auction improvements¹¹.

Finally, Denmark operates two key funds supporting CCS and CDR: the CCS Fund and the NECCS Fund. The CCS Fund is Denmark's main subsidy instrument, capitalized at DKK 28.7 billion (about €3.8 billion) and allocated via competitive bidding, aiming to deliver 2.3 million tons of CO₂ captured and stored annually from 2030. Payments are made per tonne based on verified storage, and contracts last up to 15 years. Ten companies were prequalified in the first tender round, with binding offers due December 2025 and contracts to be awarded April 2026. The NECCS Fund, with DKK 2.5 billion (EUR 330 million) in funding, focuses exclusively on negative emissions from biogenic sources. It supports direct air capture, bioenergy, and waste incineration projects. The first round selected three projects expected to capture 160,350 tonnes of CO₂ annually¹².

⁹ International Energy Agency. *France 2030 investment plan*. <https://www.iea.org/policies/14279-france-2030-investment-plan>

¹⁰ Swedish Government Offices. (2025, April 2). *Nya satsningar för att stärka Sveriges klimatomställning*. <https://www.regeringen.se/pressmeddelanden/2025/04/nya-satsningar-for-att-starka-sveriges-klimatomställning/>

Länsstyrelsen Norrbotten. (2024). *Green Public Procurement Action Plan 2024*. <https://www.lansstyrelsen.se/download/18.24b966da1939037e29423342/1733831438337/Green%20Public%20Procurement%20Plan%202024.pdf>

¹¹ See, for example, Swedish Energy Agency. (2025, February 14). *SEK 20 billion to capture and store over 11 million tons of biogenic carbon dioxide*. <https://www.energimyndigheten.se/en/news/2025/20-billion-to-capture-and-store-over-11-million-tons-of-biogenic-carbon-dioxide/> ([energimyndigheten.se](https://www.energimyndigheten.se))

¹² Danish Energy Agency. (n.d.). *CCS tenders and other funding for CCS development*. <https://ens.dk/en/supply-and-consumption/ccs-tenders-and-other-funding-ccs-development> (ens.dk); Ulstein, T., & Mørk, M. (2024, December). *Carbon dioxide removal in the Nordic countries: A status re-*
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The upshot for technology readiness is a classic “valley of death.” Horizon Europe and EIC funding skew toward early TRLs (research, proof-of-concept and small-scale transition), while the Innovation Fund and similar ETS-backed grants are calibrated to large flagship demonstrations and commercial first-of-a-kind projects; the intermediate tranche where pilots are validated, permitting and supply-chains are matured, and private capital is first mobilized (TRLs 6–8) has repeatedly been identified as under-served in EU advisory work and external analyses. The Commission’s own Expert Group on Carbon Removals and several independent reviews warn that without instruments to reduce technology, regulatory and revenue risk at the pilot-to-scale step, many promising methods will stall before they become bankable¹³.

Finally, while EU governance has raised the visibility of removals (the CRCF certification framework is now in place, which creates a pathway for market-making), current funding flows still concentrate on R&D and demonstration with limited fiscal continuity into commercial maturity. The CRCF will help standardize what permanent removals look like and thus enable market instruments, but unlocking large-scale private finance will hinge on coordinated EU-national deployment plans, de-risking instruments, and market-making demand such as a public removal procurement program or CCfDs to ensure predictable long-term revenue.

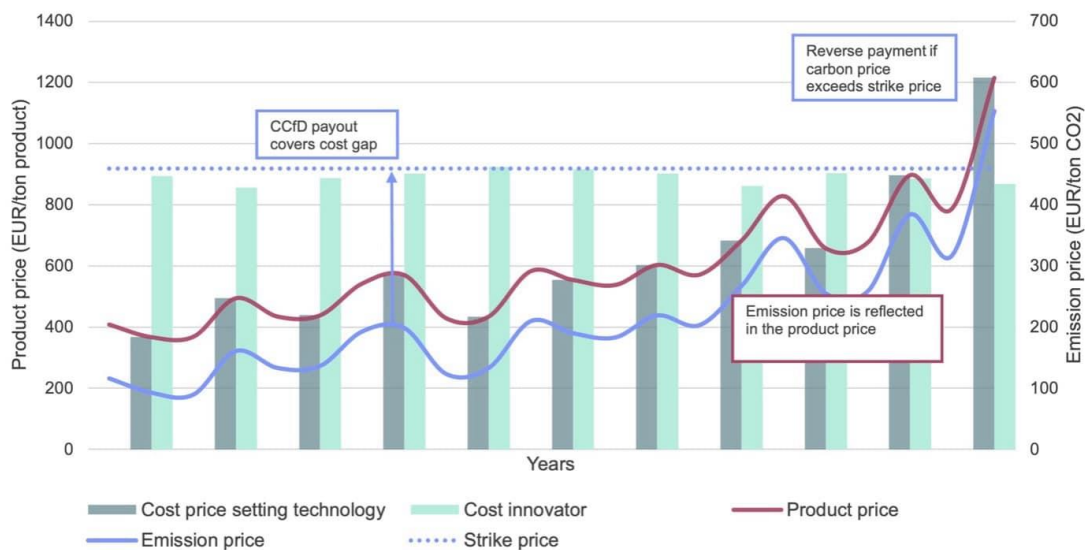
Funding Options Analysis

Carbon Contracts for Difference

CCfDs are a bilateral, contract-based hedging instrument that guarantees a fixed “strike” carbon price for a project over a long contract term: when the market carbon price is below the agreed strike the counterparty (typically a government) pays the difference to the project; when the market price is above the strike the project returns the excess to the counterparty, so the arrangement symmetrically shares upside and downside and stabilises project revenues against carbon-price volatility. This architecture, originally adapted from electricity CfDs and deployed to scale for renewables, has been explicitly analysed and recommended as an instrument to bridge the commercialisation gap for early industrial and low-carbon projects because it creates an investible, predictable carbon-price stream while preserving exposure to market signals.

port. ZERO – The Norwegian Environment Association. https://zero.no/wp-content/uploads/2025/01/Policy-paper-2025_final.pdf; Here’s the APA 7th edition reference for that article: WCCUS. (2025, May 19). *Denmark shortlists 10 companies for CCS projects*. <https://wccus.org/denmark-shortlists-10-companies-for-ccs-projects/> (wccus.org).

¹³European Commission. (2024, October 21–23). *5th EU Carbon Removals Expert Group meeting*. https://climate.ec.europa.eu/citizens-stakeholders/events/5th-eu-carbon-removals-expert-group-meeting-2024-10-21_en



Source: Hoogsteyn et al. 2025¹⁴

Many CDR pathways face a persistent price gap between the private marginal cost of removal and prevailing compliance or voluntary carbon prices, and they commonly require large capital outlays and long payback periods. By guaranteeing a remunerative carbon price per tonne removed for the duration of the contract, CCfDs directly address the two most binding commercial barriers for technologically mature but market-nascent CDR projects: price risk and revenue predictability, which together determine debt capacity and cost of capital.

Quantitative modelling and sectoral case studies show how this derisking translates into lower mitigation costs and greater bankability. A sectoral case study for steel found that well-designed CCfDs can reduce carbon mitigation costs by roughly 27% relative to a no-derisking scenario, principally through lower financing costs once a stable carbon revenue stream enables greater use of debt and longer loan tenors¹⁵. More generally, policy and project-finance analyses explain that providing secured carbon-price revenues permits projects to substitute cheaper debt for equity: because lenders rely on predictable, contract-backed cash flows when assessing coverage ratios and serviceability, projects that would otherwise be equity-heavy can attain leverage closer to the levels common in bankable infrastructure deals (i.e., debt shares that approach typical renewable-project

¹⁴ Hoogsteyn, A. (2025). Managing carbon price risk in a low-carbon industry. *Joule*. <https://doi.org/10.1016/j.joule.2025.00102>

¹⁵ Richstein, J. C., & Neuhoﬀ, K. (2022). Carbon Contracts-for-Difference: How to de-risk innovative investments for a low-carbon industry. *iScience*, 25, 104700. <https://doi.org/10.1016/j.isci.2022.104700>



leverage rather than the lower debt fractions required for first-of-a-kind industrial investments). CCfDs can then materially change the credit-profile of high-capex, high-opex CDR projects by improving debt service coverage and lowering the weighted average cost of capital¹⁶.

There is already a concrete policy precedent: Germany has competitively tendered long-term “climate protection contracts” modelled on CCfDs to support industrial decarbonisation (including projects with CCS components), offering multi-year contracts and auctions to prioritise lowest subsidy per tonne while requiring verifiable emissions reductions and milestones; the scheme has been scaled across several bidding rounds and is explicitly framed to bridge the valley of death for high-cost industrial transitions¹⁷. Building on exploratory policy work, the UK Government launched its GGRBusiness Model in August 2025, implementing Negative-Emissions CfDs as the preferred route to attract private capital for CDR deployment from the mid-2020s; the model offers 15-year private law contracts with symmetric revenue support via strike prices (initially benchmarked against voluntary market sales), up to 50% capital grants for construction, and price discovery incentives to maximise market value, while enforcing rigorous MRV under the GGR Standard, including third-party audits, permanence thresholds, and minimum quality methodologies, to ensure verifiable net removals and bridge the valley of death for high-cost engineered transitions¹⁸.

Strengths

First, CCfDs materially reduce revenue-risk for investors by replacing volatile carbon-market receipts with a contractually guaranteed strike price, which in turn lowers equity premiums and permits higher senior-debt shares and longer tenors, a structural improvement for capital-intensive CDR projects. Second, CCfDs create credible demand signals and lead markets for removal services by anchoring long-term price expectations; this can accelerate scale-up and learning-by-doing, reducing future unit costs and addressing the valley-of-death problem that blocks many first-of-a-kind CDR investments. Third, well-designed CCfDs can be competitively allocated (auctioned), which helps reveal cost-efficient projects, leverages private capital and limits fiscal exposure relative to

¹⁶European Roundtable on Climate Change and Sustainable Transition (ERCST). (2022, January 4). *Reflection note on Carbon Contracts for Difference (CCfDs)*. https://ercst.org/wp-content/uploads/2022/01/20220104-CCfD-reflection_note_final.pdf; Karlsruhe Institute of Technology. (2021, October). *Background Study Steel – Germany’s and Europe’s path to low-carbon steel production*. Agora Industry. https://www.agora-industry.org/fileadmin/Projekte/2021/2021_10_DE_KIT/A-EW_268_KIT_Background_Study_Steel_EN_WEB.pdf

¹⁷ Klimaschutzverträge. <https://www.klimaschutzvertraege.info/en/home>

¹⁸ Department for Energy Security and Net Zero. (2025, August). *Greenhouse Gas Removals (GGR) business model summary*. <https://assets.publishing.service.gov.uk/media/68ad77c2969253904d1557ff/greenhouse-gas-removal-business-model-summary-august-2025.pdf>



open-ended subsidies; auction design can also encourage co-benefits (e.g., permanence, monitoring) through qualification criteria. Fourth, CCfDs are technically flexible and can be calibrated to pay for removals per verified tonne, making them compatible with permanence requirements, leakage safeguards and phasing that accommodates technology maturation¹⁹.

Weaknesses

CCfDs expose the public balance sheet to contingent liabilities: long-dated contracts that guarantee a high strike price may generate large payment obligations if market prices remain low, which creates fiscal risk and requires transparent budgetary provisioning or capped exposure mechanisms²⁰. Administrative and transaction costs are non-trivial: governments must develop auction platforms, selection metrics, MRV capacity and long-term contract management; these capabilities are often the bottleneck in fast roll-out²¹.

Plus, CCfDs alone do not remove other risks that matter for many CDR pathways and that financial instruments cannot address (electricity feedstock price volatility for DAC, geological storage liability for CCS, biomass sustainability for BECCS).

Another problem with CCfDs is the determination of the carbon strike price, which is critical as it directly affects payment flows and the overall economic efficiency of the scheme. Setting the strike price can be challenging because it must balance providing sufficient incentives for investment in CDR while locking in payments for inefficient projects. The strike price can be fixed or variable. A fixed strike price offers long-term certainty but may not adequately adjust to changing operational or market conditions, while a variable strike price can track relevant cost indices or market realities, but increases design complexity and potential for disputes²².

Finally, a significant potential weakness of CCfDs for CDR is the risk to the financial additionality of credits. If governments essentially act as project underwriters, ensuring project funds even when no carbon credits are sold, there is a risk that these projects

¹⁹ Arlinghaus, J., Feng, S., Stemmler, J., Fankhauser, S., & Smith, S. M. (2025, May). *A taxonomy of policies to support geological carbon dioxide removal* (Working Paper 25-01). Smith School of Enterprise and the Environment, University of Oxford. <https://www.smithschool.ox.ac.uk/sites/default/files/2025-05/A-taxonomy-of-policies-to-support-geological-carbon-dioxide-removal.pdf>

²⁰ *A taxonomy of policies to support geological carbon dioxide removal* (Working Paper 25-01).

²¹ ERCST. *Reflection note on Carbon Contracts for Difference (CCfDs)*.

²² Hoogsteyn, A., Bruninx, K., & Delarue, E. (2024, December 13). *Carbon Contracts for Difference (CCfD) design: Managing carbon price risk in a low-carbon industry* (Working Paper No. ESIM 2023-07). KU Leuven, Division of Applied Mechanics & Energyville. <https://www.mech.ku-leuven.be/en/tme/research/energy-systems-integration-modeling/pdf-publications/wp-esim2023-07.pdf>

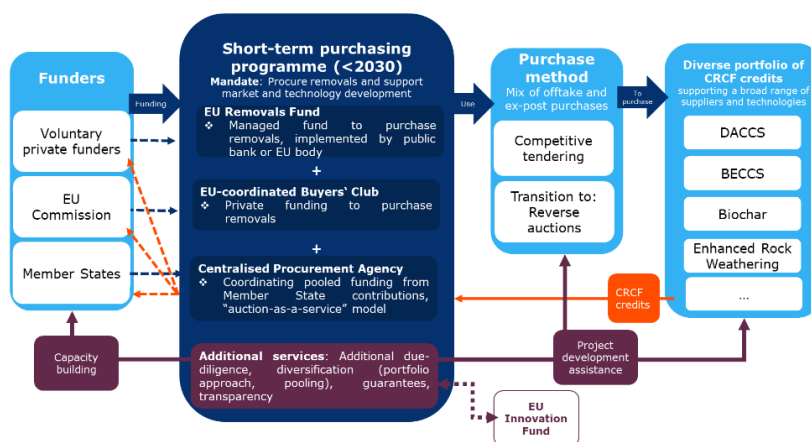


would proceed without true market demand, undermining the credibility of genuine climate impact. Resolving this requires clear verification methodologies and proactive regulatory alignment to safeguard additionality principles in CDR crediting.

Public Purchasing Programmes

Public purchasing programmes constitute a demand-side intervention that creates predictable offtake pathways for permanent carbon removal, directly tackling the market failure that early-stage CDR faces because private investors and buyers cannot credibly rely on future demand; the economics and innovation literature shows that predictable public demand reduces revenue uncertainty, increases expected returns and thereby mobilizes private capital into high-risk, capital-intensive technologies. OECD and EU analyses characterise strategic procurement as a classic demand-pull instrument that can accelerate innovation and market formation when combined with supply-side measures.

The EU's recent policy work explicitly recognises this logic: the Commission's study on an EU purchasing programme for permanent carbon removals positions EU-level public offtake as a short-term (2025–2030) market-building tool designed to complement the CRCF's quality assurance by providing the demand signal needed to unlock private investment²³.



Recommended policy design for a purchasing programme in the short term. Source: DG CLIMA & Ecologic Institute. An EU purchasing programme for permanent carbon removals

The detailed architecture of a purchasing programme matters: recent EU-level studies converge on an institutional model that pairs an EU Removals Fund (to ag-

²³ Directorate-General for Climate Action, European Commission & Ecologic Institute. (2025, August 21). *An EU purchasing programme for permanent carbon removals: Assessment of policy options and recommendations for short-term policy design*. Publications Office of the European Union. <https://op.europa.eu/en/publication-detail/-/publication/121d69d9-7f1a-11f0-9af8-01aa75ed71a1/lan-guage-en>



gregate budgetary resources and allocate financial risk across members) with a Centralised Procurement Agency (to run competitive offtakes, conduct technical due diligence, and oversee contracting). The published EU analysis argue that pooling resources at the EU level both creates larger, more predictable demand and permits deliberate portfolio design across CDR pathways, thereby achieving diversification benefits that a string of small-scale national purchases could not²⁴. Centralised procurement is also argued to capture economies of scale in transaction costs, concentrate technical and legal expertise needed to assess complex permanence and monitoring requirements, and enforce standardized procurement and quality criteria consistent with CRCF certification. From an innovation policy perspective, designers therefore recommend that a portion of any early procurement budget be explicitly reserved for higher-cost, earlier-stage removal pathways that offer superior durability or future scalability, while the remainder targets nearer-term, lower-cost removals to contain short-term fiscal exposure, an intentional “portfolio” strategy to simultaneously contain costs and drive learning.

Strengths

PPPs create an immediate revenue pathway that reduces demand uncertainty and therefore the cost of capital for nascent removal projects; procurement thus operates as a lever to convert R&D and pilot investments into bankable commercial projects, a linkage documented in OECD and EU procurement literature. By designing procurement as a diversified portfolio, programmes can accelerate learning-by-doing across multiple CDR classes, which in turn lowers unit costs over time. Centralised procurement also enables the standardisation of due diligence and contracting, professional concentration of technical evaluation capacity, and coherent alignment with CRCF certification so that public purchases strengthen market trust in the quality of removals. A well-structured public programme can send a powerful market signal that catalyses follow-on private offtakes, as governments de-risk initial supply and provide a reference price and performance standard that corporate buyers can use to underpin their own procurement decisions

Weaknesses

PPPs expose public budgets to potentially large and concentrated fiscal commitments, especially while unit costs for many engineered removals (notably current DAC projects) remain high and uncertain; recent cost surveys and IEA analysis show wide cost ranges for DAC and indicate that substantial cost reductions will require sustained learning and scale, a reality that elevates near-term fiscal risk if procurement volumes are large and not staged. There is also the political-economic risk of locking public funds into immature or lock-in-prone technologies: procurement that favours a small set of providers or

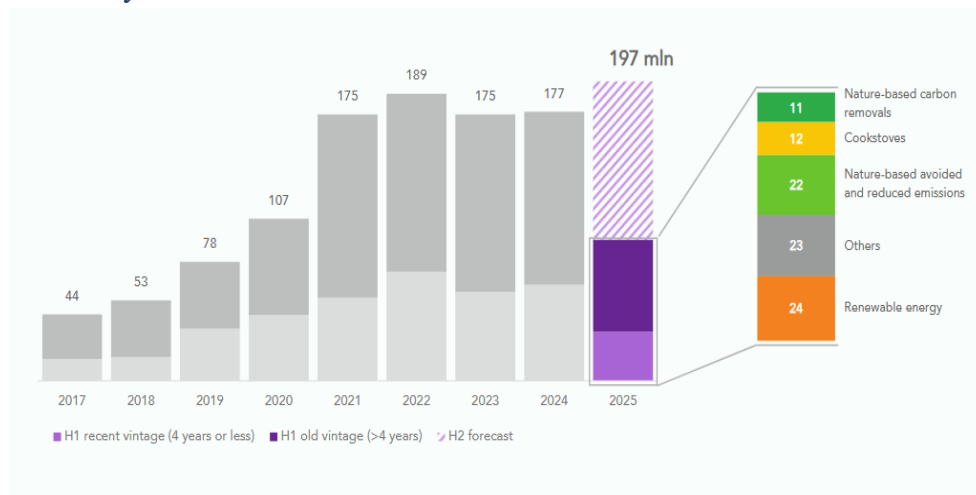
²⁴ *An EU purchasing programme for permanent carbon removals: Assessment of policy options and recommendations for short-term policy design.*



a single technical approach can create path-dependency and crowd out rival options that might prove cheaper or more sustainable as evidence accrues.

A final potential weakness of PPPs is their potential incompatibility with VCM, especially regarding co-claiming. Depending on PPP design, there can be significant challenges in combining credits purchased by governments with those traded on VCM. This can risk confusion and fragmentation in climate-related claims if the rules for ‘contribution’ and ‘offsetting’ are not clearly distinguished and governed.

Voluntary Markets



VCM Retirement Volumes in H1 2025. Source: Climate Focus, 1H 2025 VCM Review and Outlook.

VCMs currently serve as the principal demand-side driver for CDR by enabling companies to purchase credits outside of compliance regimes. They enable flexible credit purchases that help bridge funding gaps during the pre-regulatory commercialization phase of new removal pathways. For instance, Removall Carbon market intelligence reports estimate that over 145 million credits were withdrawn from the two major voluntary registries (VCS and Gold Standard) in 2024, comprising more than 110 million from VCS and over 35 million from Gold Standard²⁵. While this figure covers all credit types, it underscores the scale of the VCM and the substantial base from which CDR demand is scaling. Data from 2025 further indicate that in the first half of the year, roughly 16 million removal credits were sold, which represents perhaps the strongest start to a year on record²⁶. Moreover, the number of companies with explicit net-zero (or carbon negative)

²⁵ Removall Carbon. (2024). *Voluntary carbon market 2024: Snapshot of trends and developments*. <https://www.removall-carbon.com/en/voluntary-carbon-market-2024/>

²⁶ Carbon Credits. (2025, August 11). *Record growth in CDR credit sales drives market momentum*. <https://carboncredits.com/record-growth-in-cdr-credit-sales-drives-market-momentum/>



strategies engaging in voluntary CDR procurement rose sharply, from around 417 to 1,245 within a year²⁷.

Registry and market data further highlight that removal credits remain a small share of total issuances: between 2022 and 2024, removal credits accounted for only about 4 % of issued credits²⁸. In a broader view, the VCM has issued approximately 1.8 billion credits to date, with roughly 46% retired, whereas engineered CDR credits remain extremely limited in actual delivered volume (only ~73,628 credits or 1.9 % of total for engineered methods to date)²⁹. Forecasting indicates the market for durable, engineered CDR credits could reach US \$14 billion by 2035³⁰.

Strengths

One of the clearest strengths of VCMs for CDR scale-up is their ability to mobilise private finance quickly and at varying sizes: companies, philanthropies and investors can contract removal credits today and thereby provide early revenue that lowers investment risk for capital-intensive technologies such as DAC and BECCS, helping bring down deployment costs before heavy public subsidies or regulatory integration arrives. VCMs also reward innovation and allow a diversity of CDR approaches to be trialled in parallel, which can accelerate learning and cost declines across methods that differ widely in technological maturity, permanence and monitoring needs. Furthermore, purchasers in voluntary markets are sometimes willing to pay premiums for “permanent” or verifiable removals, creating differentiated price signals that can favour long-lived storage solutions over short-term sequestration³¹.

VCMs also operate with lower political friction than compliance instruments, which can make them a practical route for piloting governance tools (such as registries, standardized MRV protocols and permanence buffers) that regulators may later adapt into formal certification or trading systems; the CRCF framework clearly contemplates certification

²⁷ Klimate. (2025, October 29). *The role of voluntary carbon markets in scaling CDR*.

<https://www.klimate.co/insight/role-vcm-scaling-cdr>

²⁸ Carbon Direct. (2024, November 7). *Ten insights for buyers from our 2024 voluntary carbon market report*. <https://www.carbon-direct.com/insights/ten-insights-for-buyers-from-our-2024-voluntary-carbon-market-report>

²⁹ Christie-Miller, T., & Harvey, V. (2023, May 25). *Snapshot: The current carbon removal market in figures*. BeZero Carbon. <https://bezerocarbon.com/insights/snapshot-the-current-carbon-removal-market-in-figures>

³⁰ Pope, E. (2025, March 27). *Durable CO₂ removal carbon credit markets reach US \$14 billion in 2035*. IDTechEx. <https://www.idtechex.com/en/research-article/durable-co2-removal-carbon-credit-markets-reach-us-14-billion-in-2035/32898>

³¹ Green Finance Institute. (2025, July). *The role of carbon markets in financing carbon dioxide removals*. <https://www.greenfinanceinstitute.com/wp-content/uploads/2025/07/The-Role-of-Carbon-Markets-in-Financing-Carbon-Dioxide-Removals.pdf>



pathways that build on private market practice, showing how voluntary practice can inform public standardisation.

Weaknesses

A persistent and well-documented problem is credit quality: over-crediting, weak additionality tests, leakage and impermanence have been found in many nature-based projects, leading to large portions of some credit stocks being judged unreliable and to sharp declines in market value when scrutiny increases. The IPCC and multiple policy reviews stress that CDR methods are heterogeneous both in technology and permanence powers, and that this heterogeneity makes consistent, scientifically credible MRV and permanence assurances difficult to achieve at scale³².

Fragmentation and inconsistent standards across registries and protocols amplify integrity risks: different methodologies treat additionality, baseline setting, leakage and co-benefits differently, which creates opportunities for double counting and for projects to be credited more than once or to claim removals where none occurred³³.

Another important weakness for EU-scale deployment is the current mismatch between the scale of removals needed for climate targets and the supply coming through voluntary markets. Analyses find that voluntary credits from genuine removals still constitute a small share of total VCM volumes and that most traded credits remain temporary, land-based removals rather than permanent industrial storage, constraining the market's ability to finance the large, permanent CDR deployments that modelling suggests are required for net-zero pathways³⁴. This is related to the more fundamental claim that VCM, but its own nature, lacks full policy recognition, with obvious implications on demand dynamics.

Offtake agreements

Offtake agreements long-term contract between a buyer and a CDR project developer, where the buyer agrees to purchase a specified volume of carbon removal credits over

³² Intergovernmental Panel on Climate Change. (2022). *Chapter 12: Cross-sectoral perspectives*. In *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the IPCC*. Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-12/>

³³ Organisation for Economic Co-operation and Development. (2024, July). *The interplay between voluntary and compliance carbon markets: Implications for environmental integrity* (OECD Environment Working Papers No. 244). <https://doi.org/10.1787/500198e1-en>

³⁴ Ecologic Institute. (2025, February). *Scaling up carbon dioxide removals: Recommendations for navigating opportunities and risks in the EU* (Report No. 70803). Publications Office of the European Union. <https://www.ecologic.eu/sites/default/files/publication/2025/70803-Scaling-up-carbon-dioxide-removals.pdf>



multiple years, often at fixed or variable prices. This contract structure provides predictable demand and revenue streams to project developers, helping them secure financing for capital-intensive CDR projects. The buyer receives verified carbon credits over time as removals are achieved and validated, while the developer gains the financial certainty needed to scale operations. OAs differ from spot market purchases by offering a stable, phased delivery and payment schedule rather than immediate, single transactions.

OAs can also help unlock early-stage CDR deployment in the EU by giving project developers long-term revenue visibility and making projects bankable for equity and debt providers. By guaranteeing future purchases of high-quality removal credits they reduce demand risk and allow developers to raise upfront capital for CAPEX-intensive engineered removals. Corporate buyers are starting to use offtakes to secure durable removals, even as current demand for novel CDR remains thin, thereby providing proof-of-concept for business models and price discovery in the voluntary market³⁵.

Technical analyses highlight offtake-style purchasing and competitive tenders as preferred short-term tools for a European CDR purchasing programme, bridging the gap until full integration into compliance markets like the EU ETS is decided³⁶. These contracts help signal long-run demand consistent ahead of the Commission's 2026 assessment on integrating certified removals under the CRCF into the ETS.

Strengths

By locking in future purchases of verified, high-quality carbon removal credits, OAs reduce demand risk and price volatility, offering a hedge against fluctuating market conditions and rising carbon credit prices anticipated over the next decade. OAs enable early-stage CDR projects to attract private investment by making their cash flows more predictable, thereby bridging the financing gap.

OAs also contribute to demand signal clarity for the EU's carbon removal market, facilitating better planning and volume commitments aligned with EU climate targets and regulatory timelines, including integration with the EU ETS. The contract structure allows corporates to meet emission reduction and net-zero commitments by assuring access to durable removals, thus supporting the credibility and scale of voluntary carbon markets in Europe. Standardization of contract terms aligned to the EU CRCF reduces

³⁵ Arbonics. *Carbon offtake agreements: the approach leaders are taking*. <https://www.arbonics.com/knowledge-hub/carbon-offtake-agreements>; de Cointet, I. (2025, November 10). *The role of offtake agreements in bridging the CDR financing gap*. ClimeFi. <https://www.climefi.com/blog-posts/the-role-of-offtake-agreements-in-bridging-the-cdr-financing-gap>.

³⁶ Ecologic Institute. (2025, February). *Scaling up carbon dioxide removals: Recommendations for navigating opportunities and risks in the EU*.



transaction costs and complexity, fostering greater market liquidity and interoperability across Member States.

OAs further serve as a risk mitigation tool by lowering financing costs through enhanced counterparty credit risk profiles, especially when involving investment-grade buyers from stable economies within the EU. They provide a foundation for establishing a transparent, robust infrastructure for CDR supply chains, essential for achieving permanent, verifiable emission removals. Lastly, as mechanisms that bridge VCM with future compliance demands, their flexible design accommodates evolving EU regulations and market standards, addressing uncertainties linked to long contract durations and regulatory changes.

Weaknesses

OAs entail the risk of long-term contractual rigidity, which may not accommodate evolving regulatory standards and CDR methodologies under the EU CRCF (the so called “goalpost risk”). This can result in mismatches between agreed terms and future compliance requirements, potentially causing financial and operational uncertainties for project developers and buyers.

AOs also face challenges from the relatively immature and fragile demand for novel CDR technologies, with voluntary market uptake still low and uncertain in scale. This fragility impacts the reliability of long-term revenue commitments that underpin project financing³⁷.

Furthermore, the dependence on corporate buyers in voluntary markets can expose projects to reputational risks if buyers fail to meet sustainability claims or retreat due to changing priorities. On a related note, the high concentration of purchases among a few buyers, such as Microsoft accounting for over two-thirds of durable CDR contracts, may create market dependence and limits broader participation³⁸.

Integration in Compliance Mechanisms

The integration of CDR into the EU ETS offers a potentially transformative policy innovation by creating a compliance-driven demand stream anchored in regulations, rather than voluntary markets. In principle, by embedding removal credits into a market with legally binding emissions obligations, the regulatory certainty for both emitters and removers is enhanced.

³⁷ Sylvera. (2025, September 15). *Bridging the CDR gap in 2025: What are buyers and sellers looking for right now*. <https://www.sylvera.com/blog/bridging-the-cdr-gap-in-2025-what-are-buyers-sellers-looking-for-right-now>

³⁸ NewClimate Institute. (2025, September). *Companies’ role in scaling up durable Carbon Dioxide Removals*. <https://newclimate.org/sites/default/files/2025-09/newclimate-publication-ccrm-cdr-Sep25.pdf>



The UK government has stated that it aims to legislate for the integration of engineered greenhouse-gas removals by the end of 2028, with operational implementation expected by end of 2029³⁹. Meanwhile, in the EU itself, the European Commission issued a public consultation in April 2025 on integrating greenhouse-gas removals into the EU ETS and formally expects to publish its assessment of options in 2026.

Regarding the methodological architecture, a key design decision concerns whether removal credits should replace or complement traditional allowances under the cap. A recent ERCST report recommends that any removal credits be introduced as additional instruments, i.e., on top of the existing EUA cap, rather than counted within the cap so as to avoid eroding the abatement pressure inherent in the cap itself⁴⁰. This option allows the use of CDRs to be based on atmospheric concentration of CO₂ rationale and market efficiency. Having the same EUA cap maintained throughout also provides certainty on future availability of EUAs without being based on the feasibility of CDRs. In a similar fashion, despite with different integration proposals, the Ecologic Institute cautions that unconditional and unlimited inclusion of removals would effectively abolish the emissions cap, thereby undermining policy integrity⁴¹. In short, preserving the existing EUA cap while creating a complementary removal-credit demand stream is seen as critical for aligning the mechanism with atmospheric carbon-concentration objectives.

Strengths

Integrating certified CDR into compliance systems can mobilize very large volumes of private capital quickly. The EU ETS is the continent's deepest compliance price signal and, if linked to high-quality certified removals, could channel the scale of demand that many industrial CDR options require to reach commercial scale. Market buyers under a compliance scheme can create predictable, bankable revenue streams that are far larger than most voluntary markets today, which helps overcome high upfront capital costs and attracts finance for long-duration projects.

³⁹ Department for Energy Security and Net Zero. (2024, May 23). *Integrating greenhouse gas removals in the UK Emissions Trading Scheme [Consultation]*. UK Government. <https://www.gov.uk/government/consultations/integrating-greenhouse-gas-removals-in-the-uk-emissions-trading-scheme>

⁴⁰ European Roundtable on Climate & Sustainability Transitions (ERCST). (2024, March 11). *The future of the EU ETS: Carbon dioxide removals (CDRs)*. <https://ercst.org/wp-content/uploads/2024/03/20240311-ERCST-Future-of-the-EU-ETS-Carbon-Removals-Website.pdf>

⁴¹ Meyer-Ohlendorf, N. (2023). *Making Carbon Removals a Real Climate Solution: How to integrate carbon removals into EU climate policies* (Report No. 50139). Ecologic Institute. https://www.ecologic.eu/sites/default/files/publication/2023/50139_CDR_Framework_Report.pdf



Closely related is the argument that compliance demand can accelerate technological learning and cost decline. Economies of scale and learning-by-doing for engineered removals historically require policy-driven demand or procurement to move from demonstration to deployment; linking certified removals to a compliance price can create that demand and thereby lower costs over time, potentially making removals more affordable and technically mature for broader climate portfolios. The EU's advisory bodies have specifically recommended scaling CDR while attending to safeguards to harness innovation without repeating past policy design errors⁴².

Weaknesses

A governance weakness is the potential for price distortion and moral hazard within the ETS. If low-cost (or politically favoured) removal credits are allowed to satisfy compliance obligations without reducing the ETS cap, the market price for allowances could fall, softening the incentive for emitters to decarbonise.

Legal and procedural weaknesses remain an active concern: policy briefs and legal analyses have identified potential contradictions between CRCF methodologies and other legal instruments, weakly specified use cases for certified units, and the likelihood of litigation if delegated acts fail to reconcile legal requirements, scientific rigour, and market design. Such legal uncertainty could chill investment and create reputational risks for firms and public authorities that rely on CRCF units⁴³.

Design Options Analysis

CDR Methods and Funding Eligibility Criteria

Designing an EU finance architecture for CDR requires more than deciding cash flows; it requires a defensible that channels public support to removals that actually deliver durable climate benefit while avoiding perverse social or environmental impacts. The CRCF already anticipates this by tying certification (and therefore likely eligibility for many forms of public support) to the Q.U.A.L.I.T.Y criteria, a package of rules covering quantification, additionality, long-term storage (permanence) and sustainability that must be reflected in methodological guidance and independently verified certification.

⁴² European Scientific Advisory Board on Climate Change. (2025, February 21). *Scaling up carbon dioxide removals – Recommendations for navigating opportunities and risks in the EU*. Publications Office of the European Union. <https://climate-advisory-board.europa.eu/news/new-report-from-the-eus-climate-advisory-board-outlines-recommendations-to-scale-up-carbon-dioxide-removals-while-addressing-opportunities-and-risks>

⁴³ Carbon Market Watch. (2025, August). *Policy briefing on core issues with the CRCF methodologies*. <https://carbonmarketwatch.org/wp-content/uploads/2025/08/Policy-briefing-on-core-issues-with-the-CRCF-methodologies-1-1.pdf>



Permanence is central because the climate value of a removal falls with the risk and likelihood of reversal; funding and certification should therefore distinguish removals by expected residence time and by who holds liability for reversals⁴⁴. Additionality must be tested against a realistic, transparent baseline so that payments do not simply reward activity that would have occurred under existing law or market conditions; Sustainability safeguards are equally important: funding rules should exclude support for removals that impose unacceptable co-risks or negative social impacts, and should require robust quantification boundaries and sustainability safeguards, consistent with the CRCF's Q.U.A.L.I.T.Y criteria, to ensure that certified removals deliver genuine and durable atmospheric benefit.

Operationally, these high-level principles imply three concrete design features for eligibility. First, method-specific methodologies should set quantitative permanence proxies or minimum residence times and, of course, refer to the CCS Directive on matters related to long-term liability for reversal (project owner, storage operator, or state backstop) because generalized statements about “permanence” are insufficient for procurement and public finance decisions. Second, additionality tests must be standardized across funding programmes to avoid fragmentation and cherry-picking⁴⁵. Third, sustainability screening should be embedded upstream of any disbursement and finance instruments should prioritise removals with demonstrable co-benefits.

Technology Neutrality vs. Strategic Prioritization

A finance architecture must also resolve a strategic tension: should public support be technology neutral or should the EU selectively prioritise certain pathways with targeted instruments? Each choice has distinct strengths and risks, and recent policy literature and modelling offer a balanced picture to inform pragmatic design.

Proponents of technology neutrality point out that neutral, performance-based mechanisms have successfully driven cost reduction and innovation in other clean-technology domains by letting the market discover the lowest-cost ways to meet a stated outcome.

⁴⁴ While liability for reversals is a crucial issue, in many situations it does not make sense for the certification to be issued at that point. For instance, for biochar, it is best placed to certify at the biochar plant, rather than every end point of disposal/storage of the biochar. Equally, for DACCS/BECCS projects, it is better to certify at the point of capture, not final storage, especially where T&S networks combine mixed fossil and biogenic streams. Another key issue is responsibility for the upstream value chain, which will rarely be the same party as that who holds liability for reversals.

⁴⁵ Fallasch, F., Böttcher, H., Schneider, L., Herrmann, H., Jörß, W., Siemons, A., & Flohr Reija, M. (2024). *The EU Carbon Removal Certification Framework: Options for using certified removal units and funding mitigation activities* (Climate Change 44/2024). German Environment Agency. <https://www.ecologic.eu/sites/default/files/publication/2024/50122-the-eu-carbon-removal-certification-framework.pdf>



Economic theory and empirical evidence from renewables auctioning and technology-agnostic innovation prizes indicate that competition on outcome metrics can improve dynamic efficiency and avoid locking policy into premature technical bets. For CDR, a neutral approach would mean tying financing to verified quantities of net atmospheric removals (as certified under CRCF) and letting providers with lower costs or better co-benefit profiles win contracts; this can encourage incremental innovation across diverse providers and leave room for unexpected technological breakthroughs.

But neutrality has some limitations in the context of current CDR's heterogeneous portfolio. Removal methods differ widely in maturity, deployment scale potential, cost trajectories and environmental externalities, and many high-integrity methods face pronounced "valley of death" problems that purely market-based competition will not solve in early stages. Integrated assessment and portfolio modelling for the EU context therefore often find that deliberate portfolio diversification reduces system-level trade-offs and increases the likelihood of meeting cumulative removal requirements without unacceptable social-environmental impacts.

A practical compromise adopted in other sectors is to establish an overarching outcome metric (verified net removals) that governs eligibility and payment, but provide a choice of targeted instruments (innovation grants, accelerated permitting, infrastructure co-investment, and higher upfront push-payments) tailored for methods that meet strict quality screens but are demonstrably immature⁴⁶.

Policy Recommendations

A robust EU financial architecture for carbon dioxide removal must be designed to be time-limited, fiscally prudent, and technologically neutral in its overarching logic that it catalyses scale without locking the EU into narrow, long-lived market distortions. To operationalize fiscal prudence, any new instrument or program should include pre-committed budgetary caps, regular independent cost-benefit reviews, and automatic degression mechanisms that reduce support intensity as delivered costs fall or as private capital becomes available at scale. Explicit sunset clauses or staged tapering of public support (triggered by objective, transparent targets such as average delivered costs below a pre-defined threshold or a minimum volume of private offtake without public backing) protect against persistent subsidy dependence and preserve policy flexibility as evidence on removal technologies and costs trajectories evolve.

⁴⁶ Schenuit, F., & Treß, D. (2025, April). *Scaling industrial carbon dioxide removal: Policy options for a short-term strategy* (SWP Comment No. 13/2025). Stiftung Wissenschaft und Politik (SWP). <https://doi.org/10.18449/2025C13>



A deliberate sequencing of finance (early public R&D and demonstration grants followed by performance-driven private incentives) is essential to achieve value for money. Public finance is most efficient at the pre-commercial stages where knowledge externalities and high technical risk mean private capital is scarce; academic and policy literature finds that public R&D and demonstration reduce information and technical risk, increasing the likelihood that later private finance will deploy at scale⁴⁷. Within this sequencing, the EU should explicitly ring-fence a declining share of total funding for pre-commercial activities to prevent indefinite public exposure and to force a disciplined transition to private-led deployment. As technologies mature, payments tied to independently verified removal outcomes redirect public funds from input subsidies to outcome purchases (for example, paying per net tonne of permanent removal), which both leverages private capital and ensures taxpayer exposure is commensurate with environmental performance.

To bridge the “valley of death” between demonstration and commercial scale, public programmes should explicitly target de-risking: reducing revenue volatility, backstopping early-stage counterparty risk, and co-financing capital-intensive pilot deployments so that projects can reach bankable track records. De-risking instruments must remain tech-neutral in their eligibility criteria (e.g., any CRCF-certified removal pathway is in scope) but can offer differentiated contract terms (such as higher upfront capital grants or longer revenue-support periods) for pathways that are demonstrably less mature (TRL ≤ 7) or that deliver exceptional co-benefits, thereby preserving neutrality while pragmatically addressing heterogeneous risk profiles.

Competitive, performance-based procurement mechanisms, notably two-sided CfDs run as reverse auctions, are a practical instrument to convert early public support into predictable revenue streams while using competition to discover cost-efficient prices. CfD-style instruments have demonstrably reduced the cost of clean power in multiple auction rounds by providing long-term revenue certainty that lowers cost of capital, while reverse auctions discipline subsidies through competitive price discovery; independent evaluations of the UK scheme and comparative analyses show clear precedents that can be adapted to removals procurement, subject to careful design for permanence, contract length, and counterparty risk. That said, auction outcomes also demonstrate sensitivity to auction budget, strike-price ceilings, and macroeconomic shocks (for example,

⁴⁷ See, for example, Polzin, F., Pettibone, S., & von Flotow, P. (2017). Mobilizing private finance for low-carbon innovation: A systematic review of barriers and solutions. *Renewable and Sustainable Energy Reviews*, 77, 525–535. <https://doi.org/10.1016/j.rser.2017.04.006> Murphy, L. M., & Edwards, P. L. (2003). *Bridging the Valley of Death: Transitioning from public to private sector financing* (NREL/MP-720-34036). National Renewable Energy Laboratory. <https://www.nrel.gov/docs/gen/fy03/34036.pdf>



AR5/AR6 experience in the UK), so EU CDR CfD design must include flexible budget rules, indexation to avoid perverse outcomes under rapid inflation, and well-defined re-allocation procedures to maintain investor confidence.

All public and performance-based payments must be conditioned on robust MRV and permanence safeguards so finance flows only to removals that credibly and verifiably reduce atmospheric CO₂. The EU's CRCF provides a foundation for mandatory methodological consistency, registries, and third-party verification for certified removals, and international technical assessments emphasize that credible MRV requires proper emissions accounting, ongoing monitoring of storage sites, and independent verification to address leakage and reversal risks. Practically, procurement contracts and CfDs should reference CRCF-aligned protocols for baseline setting, measurement frequency, independent auditing, and explicit reversal-management mechanisms (e.g., insurance, buffer pools, or performance bonds), thereby protecting environmental integrity and investor confidence simultaneously.

In operational terms, the EU architecture should combine: (i) public R&D and demonstration grants targeted at lower-TRL removals and at MRV/permanence methods to build credible measurement capacity; (ii) a staged, auctioned purchasing programme using CfD-type contracts for verified permanent removals with clear sunset/tapering rules tied to objective maturity and cost benchmarks; and (iii) a strict MRV and registry regime anchored in CRCF and IPCC AR6 guidance so that payments are only made for net, durable removals. This mix uses scarce public capital to correct market failures early, then relies on competitive, performance-based private finance as the primary lever once technologies are bankable and verified, while retaining sufficient strategic flexibility to reallocate resources across pathways if new evidence on permanence, sustainability or scalability emerges.